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From an etching by Rudolf Stumpf

Carl Stumpf

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THE PSYCHOLOGICAL REVIEW

CARL STUMPF

"We scorn construction, love investigation, maintain a skeptical attitude towards the mechanism of a system. . . . We are content at the end of a long life to have tapped various lines of scientific research which lead to the foundation of things; we are content to die on the way." These words, by W. Dilthey, which Stumpf himself used as a motto for his autobiography seem to be indeed characteristic of him as a scientist and person. They might be viewed as somewhat representative of that period of psychology of which Stumpf has been one of the outstanding figures.

For a German graduate student of psychology around 1910, like myself, two men held the highest rank and dignity within the pyramid of psychologists actively participating in research and associated in the Deutsche Gesellschaft für Experimentelle Psychologie: Geheimrat Stumpf and Geheimrat G. E. Müller. Both men were decidedly empiricists, both had done a tremendous amount of careful and exact experimental work in a variety of fields, both had very definite ideas and were militant enough to put up a stiff fight when necessary for their views in defense and attack. Of these men, Stumpf might be said to be somewhat more representative of the transition of psychology from a philosophical discipline to an empirical science. Stumpf's theories, his interests, indeed his whole life, seem to be a mirror of this period with its specific virtues and difficulties. He himself molded this period very decidedly. Although he was not interested in building up a school for himself (he maintained a fatherly, friendly, but rather critical relation to his own pupils), he influenced his followers deeply. Many of his views have a close relation to fundamental ideas in Gestalt psychology.

As a boy of ten, Stumpf wrote his first musical composition. His love for music was strong throughout his life. It led to friendship with outstanding artists. It was one of the sources of his experimental work in tone psychology which he started in 1875 and which he actively continued with but little interruption until his last years. It was rather impressive to see the old gentleman well over eighty come from time to time to the institute, which then had been for quite a number of years under the direction of his pupil, W. Köhler, to make personal observations on the elaborate instrument he had built for the synthetic production of vowels. Four adjoining rooms were adapted to this set-up, including the room where sound was produced with the aid of compressed air (the more elegant electrical method was not yet available), the room for purifying the tones from overtones by means of dozens of interference tubes of all sizes, and the room for observation. In one of these rooms there was still an organ, which had served Helmholtz, and which used instead of pipes glass balls partly filled with paraffin. There Stumpf made his observations, sometimes employing a few subjects, but often alone with the help of the Institute's attendant.

In his second semester at Würzburg, when he was seventeen, Stumpf started to study law. Then he came in contact with Brentano whose personality and philosophy became the dominating influence on his whole thinking and career. At twenty he graduated in philosophy at Göttingen under Lotze. He entered a Catholic theological seminary studying Thomas Aquinas and observing conscientiously the ascetic regulations. Two years later, after an inner struggle and a rebirth, he left this seminary and dogmatic theology behind him. The effect of this struggle was visible even in his late years when he finally broke his connection with the church entirely. At twenty-two he became instructor at Göttingen, at twenty-five professor at Würzburg, and after a few years each in Prague, Halle, and Munich, he settled definitely in Berlin (1894).

It still took courage to approach questions of the soul experimentally in an atmosphere in which philosophy was the

accepted king and in which experimental procedures seemed to be hopelessly distant from any problems of real psychological importance. Stumpf saw the growth of the humble Seminary of three rooms, started by Ebbinghaus, into the Psychological Institute at the Schloss which had more than forty rooms; a Phonogramme Archiv under E. v. Hornbostel, containing the richest collection of primitive music; excellent equipment of psychological apparatus of all types; a department of applied psychology under H. Rupp; a film archiv; and an electrical and mechanical shop. Still it seems to me that psychology in Germany never lost entirely the somewhat apologetic aspect, a kind of inferiority complex toward its mother, philosophy.

For Stumpf there was a close relation between philosophy and psychology. Being a pupil of Brentano, he grew up within this particular type of quasi-empirical philosophy which led to Husserl's phenomenology, a philosophy as far away from any purely formalistic logic or the epistemology of Kant as from the positivism of the type of pragmatism. The ontological and phenomenological aspects of Brentano's philosophy seem to have created for Stumpf a harmony between his philosophical and psychological work. Brentano's conviction that the true philosophical method is not different from that of natural science, became his own. This attitude seems to have been strengthened by Lotze's lectures and Stumpf's later acquaintance with outstanding physicists and mathematicians such as Kohlrausch, Helmholtz and Felix Klein. Stumpf often refers to tone psychology as phenomenology. His views on the rôle of judgment and sensation in perception are definitely governed by his philosophical convictions. It was a time when discrepancies between the 'objective' structure of the stimuli and the perceptual field were classified under the epistemological concept of illusion and when for the analysis of perception only expert observers were acceptable as subjects.

The situation at the University definitely favored a certain dependence of psychology upon philosophy. The University of Berlin never had a chair of psychology. Stumpf was

Professor of Philosophy and was only in addition director of the Psychological Institute. The philosophical atmosphere at the University of Berlin was for many years dominated by the Kantianism of Riehl and Erdmann. No wonder that in comparison to these men Stumpf appeared as an empiricist. Indeed, he esteemed Locke and Berkeley higher than Kant and Hegel. His examination questions on Aristotle were much feared by the students. Stumpf published charts concerning the history of philosophy (Tafeln zur Geschichte der Philosophie) which have been widely used. He introduced the term '*Sachverhalte*' (state of affairs) which soon became rather important in philosophical discussions. He published a treatise 'Zur Einteilung der Wissenschaften' (classification of sciences) and gave much thought to the theory of probability.

In quite a number of points Stumpf stood against the prevailing current of his time. For instance, he did not believe in psycho-physical parallelism, but in interaction.

Well known are his distinctions between sense data and psycho-physical functions. The first correspond to the field of perception psychology which was viewed by Stumpf mainly as phenomenology. Although he spent most of his time in this field, he considered it merely as 'preparatory work' for the field of psychological functions, which for him was the real field of psychology. Today a considerable amount of his work in the psychology of tones, vowels and consonants may be considered mere physics and some of his argumentations may appear more philosophical than psychological in nature. Still, his views seem to have enabled him to see, not blinded by the prevailing opinion of his time, certain rather fundamental psychological facts. His discussion of nativism and empiricism in connection with space perception is history. These issues seem to me rather closely related to some of the important problems of instinct and learning of today, and although argumentation may have to be carried through on a different level, Stumpf was, in my mind, on the right side. He saw that the realm of immediate experience is much larger

than usually is recognized. He even held that causation can under certain conditions be experienced directly.

His study in tone psychology was not limited to the study of such questions as consonance or the character of the sound of different instruments. He became deeply interested in the history of music. He was the chairman of the commission which studied primitive music using as subjects primitives taken prisoner in the World War, and helped to collect in twenty years more than 10,000 records from every part of the world. He was interested in the development of modern music which started to think of using half tone intervals.

His studies in child psychology dealing with the particular language development of his own son, and in animal psychology dealing with the horse which could do mathematical problems (Der Kluge Hans) were rather inspired by the occasion; but his attempt to found an association for child psychology and his active help in establishing Köhler's studies with anthropoids in Teneriff show his genuine interest in the scientific aspect of these fields. He saw the limitations of the Darwinistic explanation of development. Although he believed that the difference between physical and biological data is only a matter of complexity, he pointed out the questions involved in the problem of teleology and emphasized the discontinuous, step-wise character of developmental processes.

Stumpf's introduction of a new class of emotions between feeling on the one side and sensation on the other, the '*Gefühlsempfindungen*' (feeling-sensations), is well known. His main psychological interest outside the field connected with tone psychology seemed to have been the problem of will. I remember clearly the seminar in which we discussed the current research in this field. Stumpf was always eager to see a connection established between the rather narrow experimental work and the more inclusive problems of the will, especially those related to criminal law.

Stumpf gave his students an unusual amount of freedom. For example, I selected my topic for a thesis and it was presented to Stumpf by the assistant while I waited in another

room. The assistant came out to tell me that the topic was accepted and during the next three or four years I spent on this work, I do not remember having ever discussed the matter with Stumpf previous to my final presentation. Compared with such an atmosphere, the now prevailing methods of research appear to be rather similar to those of a factory with both its advantages and disadvantages. In respect to the guidance of students, as in most points, Stumpf's views were quite different from those of Wundt whose name was nearly taboo in the Berlin Institute.

One can find in Stumpf's works all the outstanding characteristics of the pioneering epoch of experimental psychology in Germany: the nearness to the philosophical origin as background; the will to establish a variety of facts as rich and as well proved as possible (this was the center which kept things together); a marked predominance of perception psychology; a more or less open disappointment in this limitation, and a longing for the deeper problems of psychology, the experimental approach to which seemed so utterly out of reach. To my knowledge Stumpf has never shared the view of deep pessimism for the outlook of psychology which was noticeable among some of the younger psychologists at that time. He was rather optimistic for the final outcome, perhaps because he himself contributed so much to its progress.

KURT LEWIN

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THE ACQUISITION OF STRING-PULLING BY RATS—CONDITIONED RESPONSE OR SIGN-GESTALT?

BY EDWARD CHACE TOLMAN

University of California

It has been demonstrated by McDougall and McDougall (**9**), Adams (**1**), and McCulloch (**11**) that rats, and not merely monkeys and apes (see Köhler, **8**, and Klüver, **7**) can be taught to pull in food by means of attached strings. The initial training-in of such a string-pulling habit in rats requires, however, a special sort of procedure. From some recent experimentation with this procedure and from analysing it while in progress, I feel that it offers a nice problem for theories of learning.

I propose, therefore to present here a somewhat detailed description of this initial training-in of string-pulling and then on the basis of this description to seek to indicate why the sign-gestalt theory [1] seems to fit the account better than a conditioned reflex theory.

Descriptive Analysis of the Acquisition of String-Pulling

McCulloch describes the technique which he used in inducing string-pulling, as follows:

> On the first day each animal was placed in a discrimination box and allowed to nibble from the food pan at the front of the box [*i.e.*, the pan was already drawn in as far as it would come under the wire at the front of the box] about one gram of the standard food reward. He was then removed. This procedure was twice repeated. No additional food was given. On the second day the same procedure was followed. On the third day the rat was placed in the box and allowed to nibble from the pan. While he was eating, the tray was slowly drawn away from him. (At this time the tray weighed 50 grams.) He would clutch at the pan and draw it back again to a position in which food could be obtained. This procedure

[1] See Tolman (**14**), (**15**), (**16**), (**18**), (**20**), (**21**).

> was repeated. The tray was drawn under the lower wire until it was barely within the rat's reach, and he was allowed to draw in the tray for food.
>
> The tray was then drawn through the animal's paws until it was quite beyond reach. At this time a string extended from the food pan and passed under the lower horizontal wire to the rear of the discrimination box. In a very short time the rat would draw in the tray by means of the string. Sometimes he would secure the food by striking the string in his scrabblings for the food pan, sometimes he would clutch the string and draw it in, and infrequently he would seize the string with his teeth. After he had drawn the string a short distance for a few times, the tray was removed farther on successive trials. The first day's training ceased when an individual had drawn the string a distance of 50 cm. (11, p. 91 f.).

From having now, myself, carried out and watched this procedure on numerous occasions, I believe that this description can be expanded and separated into relatively specific steps.

These different steps can be epitomized in a table, as shown on page 197.

Let me point out certain features of this table. Columns 1, 2, and 3 represent successive moments in time. Column 3 presents the consummatory situation of eating from the pan. This terminates the behavior in each step of learning. In step (*a*) this consummatory situation is all that there is. I have indicated this fact by placing 'rat eats' in all three columns. In steps (*b*), (*c*), and (*d*), this consummatory situation is presented first but then it is interrupted and the animal returns to it only after the proper new response of pulling-in (perhaps as yet in only a relatively embryonic form) has appeared. Finally, in steps (*e*) and (*f*) the consummatory situation is not present before the response proper. The new stimulus is alone there and, only if the animal makes the proper response to the latter, does he arrive at the consummatory situation.

Finally, note the methods of hastening and reviving the response. Of these, (*x*), (*y*), and (*y'*) all appear to be means of enhancing the new stimulus—the string—whereas method

TABLE I

(1) *Preliminary to Learning*

	Column 1		Column 2		Column 3	
	Stimulus	Response	Stimulus	Response	Stimulus	Response
(*a*)	Pan In	Rat Eats	Pan In	Rat Eats	Pan In	Rat Eats

(2) *Beginning to Induce Learning*

(*b*)	Pan In	Rat Eats	Pan pulled away gently when rat's foot is on edge.	Rat pulls pan nearer again.	Pan In	Rat Eats
(*c*)	Pan In	Rat Eats	Pan pulled almost out of reach.	Rat scrabbles and catches hold of pan with mouth or paws and pulls in.	Pan In	Rat Eats
(*d*)	Pan In	Rat Eats	Pan pulled away just out of reach but still very visible; string.	Rat scrabbles and catches string with mouth or paws and pulls in.	Pan In	Rat Eats

(3) *Appearance and Development of Response Proper*

(*e*)			Pan apparently present in visual or olfactory terms but out of reach; string.	Rat seizes string with mouth or paws and pulls in.	Pan In	Rat Eats
(*f*)			String	Rat seizes string and keeps on pulling for quite a time.	Pan In	Rat Eats

(4) *Methods of Hastening and Reviving Response*

(*x*)			Pan or string pulled from rat with some force.	Rat exhibits opposing and contesting tug and then continues to pull string.	Pan In	Rat Eats
(*y*)			String with food smeared on it.	Rat picks up string to eat food and after eating starts to pull string.	Pan In	Rat Eats
(*y'*)			String jiggled.	Rat seizes string and pulls.	Pan In	Rat Eats
(*z*)	Return to earlier stages (*a*), (*b*), (*c*), and (*d*).					

(z) consists in bringing back one or more of the earlier steps (with their responses and the final consummatory situation resulting from such responses).

With, now, such a concrete and analysed picture before us, let us see how far each formula—the conditioned response formula or the sign-gestalt one—may be made to fit this picture. I begin with the former.

The Conditioned Response Formula Applied to the Acquisition of String-Pulling

The conditioned response theory, as I understand it, finds but four essential factors in any case of learning:

(I) An initial *unconditioned stimulus.*

(II) An *unconditioned response* originally evoked by this unconditioned stimulus.

(III) A new *to-be-substituted stimulus,* which in the typical experimental procedure is made to appear in temporal contiguity just before and then for a short time simultaneously with the unconditioned stimulus.

(IV) The new finally *conditioned response.* This conditioned response is either the original unconditioned response itself, or something closely related to it (*i.e.*, some fractional component of it or an anticipatory form of it) which comes to be made to the new to-be-substituted stimulus alone, even when the unconditioned stimulus no longer follows.[2]

Let us look, now, for these four types of factor in the account given above. I think a conditioned response theorist would be led to identify these four factors as follows:

(I) The *unconditioned stimulus* he would identify as the food in the pan (*i.e.*, the stimulus which appears in column 3 at all stages of learning).

(II) The *unconditioned response* he would identify as the eating of this food from the pan (*i.e.*, the response which appears in 3 at all stages of learning).

[2] I have here assumed that those holding to a conditioning theory of learning adopt essentially the 'substitute stimulus' notion of conditioning. For an extraordinarily clear and cogent analysis of both the facts and the theories of 'conditioning' see Hilgard (3), (4).

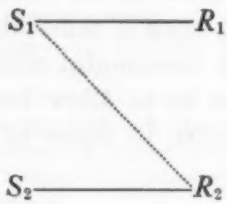
(III) The *to-be-substituted stimulus* he would identify as the string itself. (This appears in column 2 in steps (*d*), (*e*), and (*f*).)

(IV) The *conditioned response* he would identify as the seizing and pulling of the string (*i.e.*, the response which appears in column 2 in steps (*d*), (*e*), and (*f*)).

What, now, is to be said about such a conditioned response interpretation? Personally, I tend to find three difficulties with it.

First, the learned (*i.e.*, the supposedly conditioned) response of pulling the string is not, as it seems to me it should be according to a strict conditioned response interpretation, either the original unconditioned response of eating or a response 'closely' related to the latter. It is neither eating itself, a fractional component of eating, nor an anticipatory form of eating. If this pulling of the string is none the less to be conceived as the conditioned response, then the conditioned response formula must be elaborated in some way so as to include, among the conditioned responses, responses such as this one of string-pulling, which are defined merely by the fact that they *lead to* the presence of the unconditioned stimulus.

Skinner (13) alone among the conditioned response theorists seems to have been aware of this need for an elaboration of the formula and to have sought to take care of it by proposing a second paradigm for conditioned responses. In this second variety of conditioned response the *to-be-learned* response is not the original unconditioned response but a new quite different response which precedes the appearance of the unconditioned stimulus. That is to say, whereas the paradigm for the classical type of conditioned response is



that for this new type proposed by Skinner is

$$S_1 \text{———} R_1 \text{———} S_2 \text{———} R_2$$

In this latter the unconditioned response is S_2———R_2 and the conditioned response is S_1———R_1. Obviously this second paradigm fits the present case in the form:

S_1	R_1	S_2	R_2
String	Pulling	Food	Eating

The difficulty, however, with this analysis of Skinner's is, as I see it, that the pulling is not, on its first appearance, a response to the given string alone but a response rather to a whole complex relational situation. (See third objection below.) I would assert, in short, that the fact and nature of such a relational complex constitutes an important feature of the causal set-up—a feature which even Skinner's improved analysis fails to care for.

Second, the conditioned response formula seems to me inadequate in that the two stimuli and the two responses which are picked out in the above example by the conditioned response formula are not, it must be observed, stimuli and responses in any strict physiological sense. They are not physiologically, but environmentally defined affairs. Thus food and string, as visual, olfactory and tactual stimuli patterns, may be quite different from occasion to occasion. They retain their respective identities from time to time only by virtue of their environmental 'meanings.' And eating and string-pulling, as responses, do not correspond to specific and invariant sets of muscle contractions, but are only identifiable through successive times in terms of environmentally nameable 'manipulations.' If the conditioned response formula is to be retained, then it must also be elaborated and 'loosened' in some such meaningful manner. That is to say, it must be loosened so as to allow both 'stimuli' and 'responses' to be identifiable in terms of relatively gross and

meaningful characters and not in terms of any precise or necessarily constant sense-organ and muscle processes.[3]

Third, even supposing that the above two difficulties can be obviated, there still remains another fundamental difficulty with the conditioned response formula as applied here. This lies, as I see it, in the fact that such a conditioned response account allows no place for certain very important features of the actual causal situation. The only causal condition out of which learning arises, is, according to the theory, the mere temporal contiguity of the to-be-substituted and the conditioned stimuli. But in the present case the mere presence of the string and the subsequent presence of the food-pan is never enough as such, to cause the rat to learn to pull the string. The tendency to pull the string has to be induced by pulling the pan just out of reach and thereby releasing a general scrabbling (*vide* Table 1, steps (*c*) and (*d*)). The string pulling appears at first, in short, merely as a component within the more general response of scrabbling. And to release the latter a complex situational whole has to be presented. Further, the string-pulling, as such, only gradually becomes independent and specifically released by the string itself. And it appears that in this gradual development it has to be helped further by such devices as: "jiggling the string" (y'); "smearing food on the string" (y''); or "pulling the string away and evoking a contesting tug" (x); and "then continually returning to and reviving the original situation of food-can just being pulled away" (z). The value of these devices likewise would be accorded no place in the pure conditioned response account.[4] Or to sum it up, the

[3] Skinner (12) and Guthrie (2) among the conditioned response psychologists have overtly taken cognizance of this situation. But I do not feel that they have been altogether successful in their attempts. For there is a big difference between admitting that stimuli or responses probably vary from time to time and being able to give any account of (in truly stimulus response terms) why they can, nonetheless be called identical with their former selves. It is this latter requirement which I think both Guthrie and Skinner have failed to satisfy.

[4] I am not denying that a complicated form of the conditioned response doctrine such as that which Hull has been brilliantly elaborating in this journal (see, for example, 6) may eventually succeed in getting such factors in. But I, personally (I admit that I am prejudiced), always have a feeling that Hull's assumptions are too *ex post facto* to be altogether helpful.

conditioned response formula seems to me to leave out of its causal account: (1) the fact of the causal significance of the initial complex relational whole: "food-can presented and then pulled just out of reach"; (2) the fact that this situational whole releases initially merely the general response of scrabbling towards the food-can; (3) the fact that string clutching and pulling thus appear in the first place only as components within this more general scrabbling; and (4) such facts as that pulling the string away from the rat, jiggling the string, and returning again to the original total situational whole of food-can-present-then-pulled-away are causally important not only in originating but also in reviving the final perfected string-pulling response.

So much for my criticisms of the conditioned response account. Let me present now my suggested substitute for the latter—a sign-gestalt account. In the next two sections I shall present, first, a general outline of the sign-gestalt theory, and then, second, a specific application of it to this present case of string-pulling.

The Sign-Gestalt Formula

The essence of the sign-gestalt account of learning is that learning consists in the formation of new sign-gestalt-expectations—hypotheses (**20**, **21**)—with respect to the more distant stimulus-objects to be reached as a result of behaving (or not behaving) to certain more immediately present stimulus-objects. Or, expanding this statement further, the doctrine may be summarized as follows:

(1) Learning, when it occurs, arises as a result of some specific sequential pattern (spatial and temporal) of environmental stimulus-objects presented to the animal on one or more successive occasions.

(2) The consequently evoked state or process—'intervening variable' (**17**)—in the animal resulting from this presentation of the given environmental sequence is called a sign-gestalt-expectation or group of expectations or 'hypotheses.' Learning may be defined as the formation of such expectations—hypotheses.

(3) What is meant by any such expectation or hypothesis is merely some 'set' or process in the organism which is 'adjusted' to the fact that a given spatially and temporally immediate stimulus-object is going to lead, as the result of a particular type of behavior (or lack of behavior) on the part of the animal, to such and such a spatially and temporally more distant stimulus-object.

(4) The outward expression of such an acquired set is that the animal (given the proper conditions of motivation) tends to behave to the more immediate stimulus-object in either the way to get to or the way to avoid such more distant stimulus-objects.

(5) If the environment changes so that the one stimulus-object plus the given behavior no longer leads to the other stimulus-object, then this set with its consequent behavior will under normal conditions sooner or later tend to disappear (*i.e.*, to be unlearned again).

(6) The laws and principles of learning are simply statements of those types of environmental sequence and the conditions of their presentation which favor the establishment of such corresponding sets—sign-gestalt expectations.

(7) Finally, I would find it convenient to distinguish some seven different kinds of learning corresponding to some seven distinguishable classes of such environmental sequence. For the laws of any one of these seven different types of set-up may well prove to be somewhat different from those for each of the others.

Let us briefly review each of these seven classes. They may be named as: (1) *substitute stimulus learning* (*i.e.*, conditioned reflex learning proper); (2) *signal learning;* (3) *trial and error learning;* (4) *trial and error plus signal learning;* (5) *delayed reaction learning;* (6) *inferential learning;* and (7) *inventive learning.*[5]

[5] In a recent previous presentation (18) of my doctrine of learning I distinguished but four classes of learning, viz: conditioned reflex learning; sign learning; trial and error learning; and higher forms of learning.

The present seven classes have been obtained from the above four as follows. What I there called conditioned reflex learning I am now calling substitute-stimulus learning. What I there called sign learning I am now calling signal learning. What

(1) *Substitute stimulus*—In substitute stimulus learning (or conditioned reflex learning proper) the environmental conditions out of which the new sign-gestalt-expectation is formed consist simply in the presentation on successive occasions of two stimulus-objects in immediate temporal succession. In the formation of the conditioned response the second stimulus-object is made by the experimenter simply to follow the first without any activity or intervention on the part of the experimental individual. As a result, the latter develops an 'expectation' that the second stimulus-object is going to follow the first. This expectation betrays itself in the going off, at about the appropriate time-interval after the first stimulus-object, of the behavior appropriate to the second stimulus-object.

(2) *Signal learning*—The environmental conditions for signal learning are very similar to those for substitute stimulus learning. Again the new expectation is simply that such and such a first stimulus-object is going to be followed by such and such a second stimulus-object. But, whereas in the conditioned response proper the fact which testifies to and measures the strength of this expectation is the fact that the animal comes to release, as a result of the first stimulus-object, the behavior appropriate to the second, in signal learning the behavior which testifies to the new expectation is, rather, a behavior of 'getting ready for' the coming of the second stimulus-object. A typical example of what I am thus designating as signal learning would be the behavior of my dog who, when she hears the sound of my approaching car (first stimulus) has come to make the preparatory response of coming forward and being ready for the appearance of the car itself with me in it (second stimulus). Or, another example would be that of Wever's cat (**23**) which upon the hearing of the tone came to hold its breath ('flutter' response) in preparation for the coming of the electric shock. Similar behavior was also obtained by Upton (**22**) and Horton (**5**) with guinea pigs.

I there lumped into the one class of higher forms of learning I am here subdividing into delayed reaction learning, inferential learning and inventive learning. And, finally, I am here adding one wholly new class which I designate as trial and error plus signal learning.

(3) *Trial and error learning*—In trial and error learning the animal acquires an expectation to the effect that such and such an immediate stimulus-object will, *if behaved to in such and such a way*, lead to such and such a further stimulus-object. And it is the readiness-to-go-off (or in some cases *not* to go off—*i.e.*, when such further stimulus-objects are bad) of this mediating behavior which testifies to and defines trial and error learning. The classical examples are, of course, puzzle-box and maze learning.

(4) *Trial and error plus signal learning*—The environmental conditions here are a combination of those for trial and error learning and those for signal learning. As in trial and error learning the animal acquires an expectation to the effect that, *if he behaves* in such and such a way to such and such an immediate stimulus-object, such and such a further stimulus-object (*e.g.*, food or punishment) will result. But this is complicated by the further expectation that this result will come only if the first stimulus object is also accompanied by a certain type of signal. The classical example is discrimination-box learning.

(5) *Delayed reaction learning*—The environmental conditions for this are similar to those for the just preceding type save that in delayed reaction learning the signal is made to disappear before the mediating behavior is allowed. The expectation must carry over from the time the signal was present to the time in which the response is permitted.

(6) *Inferential learning*—I have coined this term to apply to those cases of learning in which the expectation that an immediate stimulus-object is going to lead to another stimulus-object arises not out of having gone from this first stimulus-object to the second but rather from the presentation to the animal of the second stimulus-object, *per se*, as so and so located within a larger total field which has also been presented. Typical examples of what I mean are the Tolman-Honzik 'insight' maze (**19**) and the Maier 'reasoning' experiments (**10**). After having learned the general path sequences, the animal is given a reward or barrier or punishment directly at some specific locus at a point distant from the entrance

and is then carried back, or allowed to go back, to the entrance and is required 'inferentially' to expect this distant reward or punishment so that he thereupon takes (or avoids) the appropriate new path for getting to such more distant point.

(7) *Inventive learning*—The environmental conditions for inventive learning are ones in which a required more distant stimulus-object can be reached only by a *new* type of behavior. The animal has to respond in a new way to a first stimulus-object which before learning he has ignored. The present case of string-pulling is an example. Also as examples under this head will come all the cases of learning to use tools such as are reported for example by Köhler (**8**).

Let us turn then in the next section to further analysis of such inventive learning as applied to the present case of string-pulling.

The Sign-Gestalt Formula For Inventive Learning and the Acquisition of String-Pulling

As we have just seen the sign-gestalt formula reserves the rubric 'inventive learning' for those cases, such as the present, in which the new sign-gestalt-expectation—the new set—which the animal achieves involves a new behavior, *i.e.*, a type of behavior not exhibited in the given situation previous to learning.

Rats have probably some innate propensity to pull strings (**9**). But in the environmental set-up of the present example they do not exhibit this propensity until after learning has been achieved.

I conceive the situation as follows. Before learning the stimulus-object "pan pulled in with food in it" releases the sign-gestalt-expectation which may be epitomized by the experimenter by the words "going to pan equals going to food." Also before learning there is in addition the further sign-gestalt-expectation to be epitomized as "scrabbling towards pan just out of reach will bring pan and food within

reach"![6] But learning consists in the establishment of the new expectation "pulling string will bring pan and food within reach." The way in which this new expectation is brought about seems to be by a clever manipulation by the experimenter so that the expectations present before learning lead 'by chance' (*i.e.*, so far as the animal itself is concerned) to the new response. And sooner or later the animal then 'gets' the required new expectation in the sense that he now does the new response of "pulling the string"—not accidentally as a mere part of "scrabbling" or of "eating food off the string" or of "responding to an opposing tug" but *de novo*. He responds in this new way directly because he has acquired the new sign-gestalt-expectation (the new set).

The laws for such a case of inventive learning thus become a series of statements as to those types of condition which favor this going off of the string-pulling *de novo* and not just as a component within 'scrabbling' or "eating food off the string" or whatever it may be. These laws are undoubtedly first of all those of *frequency* and *recency*. The more frequently and recently string-pulling has been made to occur as a part of 'scrabbling' or as an associated element in "eating food off the string," the more likely it would seem that the animal will, on a subsequent occasion, proceed to pull the string directly.

There must, however, be other laws besides these of frequency and recency. Learning to pull the string does not occur, or at least so I am assuming, merely as the result of a simple associationistic attachment of the pulling response to

[6] I cannot emphasize too strongly that when we thus express the content of sign-gestalt-expectations in words we do not mean to imply that such expectations also exist in this verbal form in the rat or indeed that they constitute any sort of conscious process in the rat. A sign-gestalt-expectation is simply a *set* in the animal defined by the fact that it leads to a certain type of behavior in the given situation and that it only continues to lead to this behavior so long as a certain arrangement of objects in the environment does actually obtain. The 'set' and the resulting behavior are appropriate to this environmental arrangement and prove to be contingent for their continued occurrence on successive presentations of this arrangement. This is all there is (in a good operationalism) to such sign-gestalt-expectations.

the string stimulus. Mere frequency of string-pulling as a component within 'scrabbling' or within "eating food off the string" etc., does not simply, as such, attach this string-pulling to the stimulus of "string leading into box." But rather, according to my belief, it is the repetition of such occasions of induced string-pulling together with the resulting further stimulus-situation of "pan drawn in and food within reach" which causes a new sign-gestalt-expectation to develop. That is to say, if the induced string-pulling did not result in the subsequent stimulus-situation of "pan within reach," any amount of chance string-pulling would not cause this string-pulling as such to be stamped in.[7] It is not the mere frequency with which string-pulling occurs in the presence of the string but also the frequency with which this response leads to the resultant further stimulus-situation of "pan and food within reach" which determines learning.

But there are still other conditons for such learning. Such learning as we are conceiving it, is the growth of a new sign-gestalt-expectation. And the occurrence of the learned response is in itself merely an external evidence (given such and such demand conditions) of this new expectation. Hence among the conditioners of this new expectation should be ways of presentation of the whole set-up which will tend to be more favorable to the development of the new set than will others. Learning in the present case is the growth of the expectation "pan to be pulled in by string" out of the simpler expectation "pan to be scrabbled for." And it seems certain that some ways of introducing the rat to this whole situational complex will be more favorable than will others.[8] It must be

[7] It is here that my doctrine differs essentially from Guthrie's (2). According to Guthrie the essential problem for the experimenter who would induce learning is to make the required new response occur in the presence of the given stimulus. For him such repeated occurrence will be, as such, enough to produce learning. For learning, as he sees it, is merely the associationistic ('conditioned') attachment of said response to said stimulus.

[8] It may be noted that this growth of the new set tended to make its appearance in the present case in a relatively sudden, saltatory fashion. In other words, the experimenter could practically always tell the particular occasion when the animal 'got' the new sign-gestalt-expectation. On such an occasion the animal, for the first time, seemed to seize the string directly ("and as if he knew what he was about").

confessed, however, that, as yet, we have but little information as regards such, let us call them, 'situational' laws. The necessary experiments have not been carried out. It seems certain, however, that such 'situational' laws are important and will in some degree vary from individual to individual.

Summary

(1) The learning of rats to pull in strings to get food presents a problem for theories of learning.

(2) A conditioned response type of theory applied to this case appears inadequate.

(3) The writer suggests the sign-gestalt theory.

(4) The sign-gestalt theory conceives learning as consisting in the formation of new sign-gestalt-expectations (hypotheses).

(5) A sign-gestalt expectation (hypothesis) is to be defined as an 'intervening variable'—a set—in the animal whereby the latter adjusts for the fact that such and such a spatially and temporally immediately present stimulus-object will lead (as the result of a particular type of behavior or lack of behavior on the part of the animal himself) to such and such a spatially and temporally more distant stimulus-object.

(6) An analysis of the types of environmental situation in which, and relative to which, such new sign-gestalt expectations may be induced suggests the sub-division of learning into seven types, to wit: (1) substitute stimulus learning (*i.e.*, conditioned reflex learning proper); (2) signal learning; (3) trial and error learning; (4) trial and error plus signal learning; (5) delayed reaction learning; (6) inferential learning; and (7) inventive learning. The laws for any one of these seven sub-types may well be somewhat different from those for each of the others.

(7) The present case is to be classified as one of inventive learning.

(8) In this present case the new response "pulling the string" is to be brought about in the first instance as an 'accidental' part of the working out of the already, initially, present sign-gestalt-expectations. This new response has

as its consequence, however, the presence of a further stimulus-object "pan and food within reach." And it appears that eventually the rat 'gets' the new sign-gestalt-expectation—to wit: "behaving to the immediately present stimulus-object 'string' is going to lead to the further stimulus-object 'food and pan within reach.'"

(9) The laws of this learning—this getting of the new expectation or set—would seem to be:

(*a*) That the more frequently and recently the pulling response has been induced the more likely the new sign-gestalt-expectation is to arise.

(*b*) That certain types of environmental arrangements will undoubtedly be more successful than others both for initially inducing this pulling and for causing to result from it the new sign-gestalt-expectation. As to the exact character of these, as we may call them, 'situational' laws we can at present, however, say almost nothing.[9]

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[9] Since writing this article I have had the opportunity of reading the manuscript of a forthcoming article by Harold Schlosberg entitled 'The Relationship Between Success and the Laws of Conditioning'. If I had read Schlosberg's article first, I would have modified some of the above statements.

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NOTE ON METHOD

BY DONALD K. ADAMS

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For some years now Professor Clark Hull has been instructing psychologists, by both precept and example, in logic and scientific method. He would doubtless be gratified at such concrete illustration of the effectiveness of his teaching as an attempt to apply it to his own doctrine. One can only applaud when he urges that a system of scientific theories be internally consistent, that it constitute a deductive system with the minimum necessary number of assumptions and that specific implications of (deductions from) these postulates be checked by empirical fact. Competent psychological theorists—and there are some—have always practiced these things. The burden of his complaint about current theories would hence appear to refer to their want of attention to his other requirements, namely, clarity and explicitness in definitions and postulates. For examples of these virtues he refers us to Newton or, in case we "may not be overly familiar with the technical details of classical mathematical physics," to Euclid.

This is good counsel indeed. If, as history seems to indicate, the several sciences are going in the direction of deductive systems (some would say, even, *a* deductive system), it behooves us to look at geometry, the deductive system *par excellence*. The geometers have had ample time—two thousand years—and practice aplenty in handling such systems and we may well learn from them. It might be noted in passing that it took the geometers their 2,000 years to make the definitions and postulates of Euclidean geometry explicit, in the sense of leaving as little as possible undefined, and they are not satisfied yet: this in a system that is purely deductive, in which the selection of postulates is *wholly* arbitrary and which is not required at any point to check with

empirical fact. But, evidently on the assumption that psychologists are much cleverer than geometers, Hull demands that the definitions and postulates of each psychological theory be clearly and explicitly stated at once. Moreover, he shows us by example how to do it.

When is, say, a definition clearly stated? What does the clear statement of a definition presuppose? Does it not presuppose *undefined terms?* Hull says nothing about these and *these are among the 'entities' to which the methodological principle of parsimony*[1] *most properly applies.* Let us follow Hull's suggestion and look at Euclid. Here are some of his definitions:

A *point* is that which has no parts.

A *line* is length without breadth.

A *straight line* is a line which lies evenly between two of its points.

"These definitions serve to illustrate how it is necessary to define a term in terms of something else, the meaning of which is assumed known. The terms 'part,' 'length,' 'breadth,' 'lies evenly' are undefined. These definitions are entirely superfluous, in so far as they do not enable us to understand the terms defined, unless we are already familiar with the ideas they are intended to convey. It is probable that Euclid himself did not regard these as real definitions. He probably regarded the notions of 'point,' 'line,' 'straight line,' etc., as primitive notions, the meaning of which was clear to everyone. The definitions then merely serve to call attention to some of the most important intuitional properties of the notions in question" (**2**, p. 10).

I quote from an eminent geometer, who further defines the starting point of a deductive system as "a set of undefined terms and a set of unproved propositions such that every other term can be defined in terms of the former and every other proposition derived from the latter by the methods of formal logic" (**2**, p. 9).

One need not be an intuitionalist in mathematics, nor, indeed, 'overly familiar with the technical details of classical mathematical physics' to perceive that, unless one is to get

[1] "*Entiae non sunt multiplicanda praeter necessitatem.*"

into obvious vicious circles, *some* notions *must* be left undefined. The process of stating definitions clearly and explicitly (which took the stupid geometers so long) is precisely that of finding out how *to leave the fewest possible and most immediately evident notions undefined.*[2] This question obviously does not seem to have occurred to Professor Hull. Here is definition III from his 'miniature system' (1, p. 501):

> "III. An 'excitatory tendency,' as emanating from a stimulus, is a tendency for a reaction to take place more certainly and, in case it does occur, to do so more vigorously, other things equal, soon after the organism has received said stimulus than at other times" (1, p. 501).

Count the undefined terms. Or follow them back and see where they lead. What, for example, is a 'tendency'? Is it a force? What *has* the 'tendency'? The 'stimulus'? Is a stimulus a physical event or a relation between a physical event and something else, or a psychological event? How does a tendency 'emanate' from a stimulus? Through what medium? If consistent answers be given to such questions do we not discover concealed undefined notions that have not been exhibited (*e.g.*, mind, psychological space, etc.) and of the assumption of which the definer is not aware, some of which he might scornfully repudiate? Are either these undefined terms or those defined supposed to be "primitive notions, the meaning of which was clear to every one," except such dolts as the present writer? Or has Professor Hull neglected his own precepts touching clarity and explicitness? Such terms as one may decide, after reflection, to leave undefined ought to be 'exhibited,' as the logicians call it, perhaps by pointing to examples. Thus if we were told that tendency emanation from a stimulus were comparable to radium emanation, clarity would be, *to that extent*,

[2] Thus Hilbert's set for Euclidean geometry has five undefined terms (point, straight line, plane, between, congruent) and twenty-one assumptions. Veblen's has only two (point, between) of the former and twelve of the latter; Pieri's, respectively two (point, motion) and seventeen. Choice among these may, of course, be made on other grounds than 'explicitness,' *e.g.*, facility of deduction of the rest of the system.

served. Most of the numerous undefined terms in Hull's eleven definitions and fourteen postulates are so far from primitive notions immediately clear to every one, as undefined notions ought to be, that they raise a great many more such questions. If we inquire what these undefined terms *must* mean in order that the theorems may follow from the definitions and postulates, we come upon notions which he explicitly repudiates, whereas his precepts demand consistency. If, on the other hand, we leave them undefined, his definitions and postulates are neither so clear nor so explicit as those of many psychological theories. The latter may, to be sure, not have labelled and numbered theirs but, as we have seen, clarity and explicitness require more than such mechanical devices.

Hull is quite right in saying that the implications of a theory must be empirically (not however, necessarily experimentally) checked. But he evidently has an erroneous notion of what this procedure proves. As he uses it, it doesn't prove anything, for he tells us that "truth, for the purposes of the present paper, is to be understood as a theoretical deduction which has been verified by observation" (1, p. 512).

Consider the logic of this. Major premise: If this theory is correct, under conditions *A* event *a* must occur. Now if the deduction is what Hull calls 'verified,' we have for the minor premise: Under conditions *A* event *a* occurs. We have "affirmed the consequent" of an hypothesis, which proves nothing whatever, though many others beside Hull write as if it confirmed the theory. To use a time honored example:

Major premise: If Socrates is a man, Socrates is mortal.

Minor premise: Socrates is mortal. Obviously it does not follow that Socrates is a man. Various other creatures are mortal.

The only thing about a theory that can be proven in this way is that it is wrong: Thus

Major premise: If this theory is correct, under conditions *A* event *a* must occur.

Minor premise: Under conditions *A* event *a* does not occur.

∴ This theory is not correct. This time we have "denied the consequent" empirically and this procedure has demonstrative force.

In all fairness, it should be said that in other places Hull seems to recognize that it takes many cases of fulfilled deductions to 'verify' a theory. But if we lean over backward with the best will in the world, it is still evident that he does not realize that this sort of 'verification' is wholly *inductive*. For he insists repeatedly upon the greater demonstrative significance of the obviously fallacious affirmation of the consequent when the deduction is made *before* the 'confirmatory' observation. Thus he says: "Of particular significance are those [experiments] which have not been previously carried out or even planned. It is among these latter, especially, that crucial tests of a theoretical system will be found. For this reason it is especially desirable for the advancement of science that the proponents of theoretical systems publish their deductions of the outcome of as yet untried experiments" (1, p. 495). Later he says of his theorem VIII: "When this deduction was first performed our logic seemed to be carrying us into a topsy-turvy world, but our postulates presented us with no alternative; scientific theory is concerned with inflexible logic rather than with predictions based on intuitions or wishes. A year or two after the deduction was made, Ward submitted it to a critical experimental test and found the theoretical expectation fully and completely substantiated" (1, p. 500). On the same page two further instances of such 'experimental confirmation' after the deductions are emphasized. Again he says: "Indirect verification occurs when a deduction from a combination of postulates is observationally confirmed" (1, p. 510).

It is very nice, of course, when a theory leads us to new and otherwise unexpected fact: and a theory that does it is, *ceteribus paribus*, 'better' in a very practical sense than one that can not. But why, granted 'rigorous' deduction, does it make any logical difference whatever whether the deduction is drawn before or after the experiment? What makes a

post-prediction test more 'crucial' than a pre-prediction test? The denial of the consequent kills the theory equally dead in either case. The affirmation of the consequent is in either case equally a *non sequitur*.

Up to this point I have dealt with formal matters which hardly admit of opinion. I wish now to submit for discussion a proposition that may be debatable: a 'miniature system' in an empirical science is meaningless and self-contradictory. In mathematics, to be sure, where a system is *ipso facto* limited by its definitions and postulates, themselves arbitrary, such miniature systems can be and frequently are made (*e.g.*, **2**, pp. 36–53). But in an empirical science, as Hull points out, if the consequent be denied, you *change the system*. Consequently, a 'miniature' system in an empirical science is either (1) an *ad hoc* hypothesis to explain a particular, arbitrarily limited group of facts, in which case it is unworthy of serious attention, or (2) a young total system, in which case one is justified in demanding of it at least potential adequacy to the entire range of facts of the particular field concerned. If the latter, Professor Hull's 'miniature' system would have to be called upon to show its adequacy not only to nonsense syllables in a 'rote series' (the subject of his definition), but to other learning phenomena, if not to the whole range of psychological fact. There are other criteria than explicitness to be used in comparing explanatory systems. One of these is range of adequacy. It can not be evaded by labelling a system 'miniature' for a miniature system that really evaded this test would be merely an *ad hoc* hypothesis. As many of these can be made as there are facts to be explained.[3] They could hardly be called science.

Summary

One of the 'miniature' systems offered by Hull as a model of scientific method is examined and found wanting in clarity and explicitness because of the large number and the ob-

[3] Since this was written, Professor Hull has circulated another and *quite independent* 'miniature system,' dealing with adaptive behavior.

security of the undefined notions used in its definitions and postulates. His description of the hypothetico-deductive method is found to be confused as to the nature of 'confirmation.' It is argued that a 'miniature system' is meaningless and self-contradictory in empirical science.

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A COMMENT ON DR. ADAMS' NOTE ON METHOD

BY CLARK L. HULL

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I am glad of the opportunity presented by the editor of the PSYCHOLOGICAL REVIEW to comment briefly on Dr. Adams' note.

I quite agree that neither of the two miniature theoretical systems which I have published is a flawless example of deductive procedure. In view of the great difficulties of mathematics in this respect, it is perhaps too much to expect perfection at a first attempt in the complex field of mammalian behavior. It was hoped that the general understanding of the undefined terms in the postulates would be in sufficient agreement with my use of them for the logic of the deductions to be followed without serious difficulty. Dr. Adams is justified in his complaint that the term *stimulus* is not defined. The difficulty is much too deep-seated, however, to be resolved by a mere definition. By utilizing the principles of convergent excitatory tendencies (**2**, 34 ff.) and generalization (**1**, 60) it is believed that the matter can be clarified. The publication of a somewhat detailed examination of this important matter is planned.

In regard to the bearing of an agreement between a theorem of a system and a relevant observation, upon the validity of the postulates from which the theorem was derived, I may say that my reasoning has not been what Dr. Adams supposes. A brief indication of my position in this matter is contained in a recently published study (**4**, 9) and need not be repeated here.

So far as the problem of the 'miniature system' is concerned, both of those which I have published (**3**, **4**) are to be regarded as young, but not total, systems. Strictly speaking,

I suppose they should be regarded as fragments of a single system in the making. Both theorem sequences were selected for illustrative purposes from considerably larger theorem aggregates available at the time; the first sequence (**3**, 501 ff.) has since been converted entirely into equations susceptible of mathematical manipulation and at present includes ninety deductions, the results of which presumably are capable of experimental test.[1] The *ad hoc* aspects of small deductive systems have already been discussed rather fully elsewhere (**4**, 8 ff.). It is in just this connection that we find the value of deducing the outcome of experiments and observations not yet made.

In concluding this comment I should like to express the hope that the controversy over the validity of my illustrative materials will not obscure my main thesis. While it is true that both of these examples represent definite convictions on my part, they are actually only secondary to the larger issue. This larger issue is whether we shall be able with postulates of *any kind whatsoever* to develop verified deductive systems analogous to those now available in the physical sciences. I do not share Dr. Adams' view that such systems have been derived to a considerable extent in the field of *Geisteswissenschaft*. Indeed, a large portion of the scientific world seems to believe, according to the neo-Kantian tradition, that to utilize such a natural-science method in the social sciences is not only impossible but inconceivable. I regard this belief as probably wrong and, if so, as thoroughly vicious because it prevents social scientists from developing the implicational symbolic constructs which might give their sciences power. The only convincing way to show this tradition to be false is to do what it says we can not do. Every gain in this respect by any of us should be a source of rejoicing to all, regardless of our predilections for particular sets of postulates.

[1] An experimental program designed to test these deductions has been under way for some time. Not all the deductive predictions thus far tested have been verified. The publication of a detailed account both of the mathematical deductive processes and of the experimental work is planned within a year or so.

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ADAPTATION WITH NEGATIVE AFTER-EFFECT

BY JAMES J. GIBSON

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Psychologists have in the past directed a great deal of effort toward classifying the sensory categories of our world—distinguishing, delimiting, and introspectively analyzing its qualities; but they have spent very little time in noting or studying the functional similarities which cut across these categories. That red, sour and warm are distinct experiences, based on different processes, has been emphasized to the neglect of the fact that they all manifest adaptation and other phenomena in common. Holt and Yerkes (**12**) prepared in 1903 a laboratory manual of experiments on sensation in which the emphasis was laid upon phenomena common to the various modalities and qualities—latency, after-image, adaptation, contrast, fusion, inhibition, and others—and in general upon the similarities between the senses rather than the differences. But this lead has not been followed in experiments to any significant extent.

The fact that the simpler sensory processes often behave in a strikingly analogous way to reflex processes with regard to such phenomena as threshold, latency, summation, inhibition and after-discharge should indicate that it would be profitable to look for common principles underlying the various senses. It is hardly probable that every sense is, so to speak, a law unto itself. The similarities which cut across sense departments point to the possibility of new categories and concepts in sensory psychology which might be of great theoretical value.

It is the purpose of this paper to describe in general terms one principle which can be found to apply to a variety of sensory dimensions and to exemplify it wherever possible. The principle is that of *adaptation with negative after-effect.* This lengthy phrase will generally be used in preference to

successive contrast because the latter term may imply an after-effect without correlative adaptation. It is clear, of course, that there are forms of sensory adaptation not accompanied by any negative effect, but on both logical and evidential grounds it seems certain that there cannot be a negative after-effect without adaptation. It is also clear that there are after-effects of sensory stimulation, such as the positive after-image and 'after-discharge,' which are not negative or opposite and hence are not included in the principle.

A generalized statement of adaptation with negative after-effect is as follows: *If a sensory process which has an opposite is made to persist by a constant application of its appropriate stimulus-conditions, the quality will diminish in the direction of becoming neutral, and therewith the quality evoked by any stimulus for the dimension in question will be shifted temporarily toward the opposite or complementary quality.* To take an example from the most obvious source, if a blue stimulation is prolonged, the hue loses saturation or approaches gray. Any other color stimulus which is now applied will be found to produce a hue which is shifted toward the yellow. A saturated blue is less saturated, a weak blue is gray, a gray is yellow, and a yellow is more yellow.

This formulation employs several notions which need examination: *dimension, opposite, neutral, appropriate stimulus* and *shift.* It is not a new idea that sensory qualities fall into dimensions, continua, or series (**4**). In fact, the psychophysical method by which nearly all research on sensory processes is accomplished—the judgment of 'more' or 'less'—presupposes that a dimension exists. Discrimination implies a serialization of the qualities discriminated. What needs to be pointed out here is that there are a number of types of such dimensions. A sensory continuum such as pressure, or size, or olfactory intensity, or distance, or duration is not the same kind of continuum as one like temperature (warm-cold) or brightness (white-black) or kinæsthetic right and left, or simple linear shape (convex-concave). The former is what might be called a unilateral or *intensive* dimension, the latter a bilateral or *oppositional* one. In the first type the qualita-

tive series runs from zero, *i.e.*, an absolute threshold, up to a maximum. The ends of the series are conventionally indicated by such terms as low and high, weak and strong, or little and great. The quality is the same throughout the series. In the second type, however, the series runs from a maximum of one quality through a neutral quality to a maximum of an opposite quality.

An *opposition series* of this sort has interesting properties. First, the two qualities intensify as they deviate from the neutral or, conversely, diminish as they approach the neutral. Second, the qualities may be said to cancel each other in a real, physical or physiological, sense. Third, they are complementary opposites; each presupposes the other. Hence an opposition series is not merely two intensive series with a common zero-point. Fourth, the neutral quality is unique. It is neither the one quality nor the other, but the point of departure for both of them. It is usually precise—discriminated with great acuteness—as is gray between blue and yellow or the neutral point between warm and cold. Fifth, the two maximum qualities constituting the limits of the series may or may not be precise and specific. These maxima may be set by physiological factors of sensitivity (*e.g.*, the upper threshold for speed of visual movement) or by a transition to a different sensory dimension (*e.g.*, cold into pain). Sixth, the neutral quality is the norm or standard of the series, with reference to which absolute, as distinct from relative, judgment is possible. Significantly it also corresponds to the average or the most frequent stimulus condition. In some cases the limits of the series may serve also as standards of reference when they are sufficiently specific. In the brightness-series, for example, black and white are more precise norms than middle gray.

The opposition of the two qualities deserves a further explanation. It probably consists in the fact that the same object can not be made to carry both qualities at the same time. The same surface can not be both blue and yellow, or warm and cold; the same line can not be both concave and convex; the same object can not appear to move both up and

down or to be felt both to the right and to the left. These qualities and their conditions are incompatible. Whether the opposition is ultimately physiological or ultimately physical is not so important for our purposes as is the fact that if one attempts the operations necessary to produce in a subject both qualities simultaneously, one is thwarted. The one operation cancels or negates the other and the resulting sensory process corresponds to the neutral or normal quality.[1]

Qualities may fall into other types of dimension than the two described.[2] Notably there is the type which consists of the transition between two different but not opposite standard qualities. Examples would be: red to yellow, fragrant to ethereal, the transition from one shape to another, or the series of varying orientations from a square to a diamond. The three types which have been distinguished are the *intensive* dimension, the *oppositive* dimension, and the *transitive* dimension. Only the second of these is of immediate interest to this discussion since our thesis will be that *whenever experiential qualities fall into an opposition-series, then adaptation with negative after-effect may be expected to occur.*

The quality evoked by any stimulus of the dimension in question will be shifted temporarily toward the opposite quality. This statement means that not only the quality normally evoked by the persistent stimulus but also any other quality in the series is shifted from its usual stimulus-base. There has been produced an alteration in the correspondance between stimulus and quality throughout the series. In other words, we must take into account not only the sensory dimension but its correlative stimulus-series. A prolonged stimulation, if it is not at the neutral center, will result in a change of the stimulus-response correspondence throughout such that the discrepancy between the sensory quality and the norm is reduced or in some cases even destroyed.

The fact that the prolonged application of a single stimulus-value may modify the sensory equivalences of all other

[1] An interesting treatment of opposition from a logical and philological point of view is given by Ogden (16). It is clear however that the problem of the nature of opposites is exceedingly confused.

[2] Auditory pitch perhaps constitutes a type of its own and can not be classified.

stimulus-values in its series is important. There is implied still another property of the opposition-series as a type of sensory dimension, namely, that it is in some sense a unit. The qualities which make it up are wholly interdependent; when one quality is changed, all the potential qualities are changed with it. This fact points to a much more general hypothesis with which we shall deal later, namely, that if every sense-quality falls on a dimension of some type, and if every dimension is a functional unit, as is the opposition-series, then it is possible to speak of *a* sensation and *a* stimulus only so long as one means a point on a scale. Only so long as one bears in mind that correspondences between such sensory and stimulus points are individual cases of a coherent system —a serial correspondence which may be changed as a whole— can the terms be accurately employed. This is a point which has been emphasized by Koffka (**14**). A sensory dimension is functionally 'all of a piece'; the series is a discriminatory unit.

The hypothesis in general is that adaptation and negative after-effect are to be conceived as a process of adjustment and readjustment of the physical-phenomenal correspondence of a certain type of sensory dimension, under the influence of a tendency for sensory activity to become normal, standard or neutral.[3] The formulation described can be shown to be applicable to a number of types of sense experience, and the rest of the paper will be devoted to these applications.

Color—"Chromatic adaptation," as Troland has said (**22**, p. 181), "operates so as to shift the hue which is evoked by any stimulus in the direction of the complementary of the adapting stimulus." The negative after-effect of color, being closely confined to the stimulated area of the subjective field and being subject to the tendency of all visual processes to be projected, has been called an *image* and there is a temptation to think of it as thing-like—as akin to a stimulus or at least to a retinal process. But that it is equally well conceived of

[3] The terms *normal*, *standard* and *neutral* will all be used to characterize the mid-quality of a sensory opposition series, since these different shades of meaning can not be compressed into one term.

as a temporary shift in the stimulus-quality correlation, a little reflection will show.

The examples already discussed have shown how our formula may be applied. Among the chromatic qualities, any number of opposition-series may be plotted between complementary hues, the familiar ones being red to blue-green, yellow to blue, and green to purple. All these dimensions must make up a single system, since the interesting fact is that chromatic adaptation along one dimension produces a change in all color-equations, not merely the dimension concerned. It is as if a prolonged hue became shifted toward the neutral center of the color-circle carrying with it all other points of the circle including non-complementary ones.[4]

Brightness—The occurrence of adaptation with negative after-effect in the case of brightness is less obvious than it is for the chromatic qualities. The dimension is determined in a more complex manner, since both photopic and scotopic vision enter into the picture and since brightness may refer either to whiteness of a surface or the illumination of the general field. Furthermore, the physical intensity of the stimulus corresponding to the neutral quality may vary widely. Nevertheless, events seem to be essentially the same; a positive brightness-value of the stimulus decreases in the direction of becoming neutral and accordingly the qualities shift all along the line. What was formerly dark becomes still darker, the former neutral is now dark, etc. 'Sensitivity' has been lowered for all stimulus-intensities. The converse holds if a negative stimulus is applied, *i.e.*, a stimulus of lower physical intensity than that of the neutral level. In this case the 'sensitivity' of the visual mechanism has been heightened and all brightness values shift upward on the scale (**22**, p. 93 f.). This formula seems to apply both in photopic and in scotopic vision. It fits not only the facts of the familiar laboratory demonstration using black, gray, and white papers, but also the results of the more precise experiments using

[4] A lowering of the brightness of the adapting hue, however, may apparently upset the simple rule of a shift in the complementary direction. The 'dimming effect' reported by Troland (**20**) yields after-effects of chromatic adaptation into which other factors enter.

luminous stimuli. It also corresponds to the facts of 'light' and 'dark' adaptation, where the after-effect obviously does not take the form of an after-image. A feature of this latter phenomenon is, in our terms, that the adaptation may be complete, which means that the persisting quality may not only shift toward, but may become, the neutral or normal quality. The general level of brightness-adaptation may shift up or down the scale with great freedom. A *localized* adaptation process, on the other hand, is commonly both chromatically and achromatically incomplete; according to Troland (**21**), the hue never reaches a neutral gray except with a low saturation to begin with.

It is true that the black-white series does not have a sharply defined neutral mid-point which furnishes a standard for the dimension, although, since Hering, middle gray has often been urged as unique, but it is still true that the brightness series is more nearly an opposition-series than it is an intensive series. For one thing there is apparently no possibility of a visual 'silence' or lack of sensation. Psychologically there is no visual zero with nothing below it, black or darkness being an actual quality. The conventional treatment of brightness adaptation in terms of the variable sensitivity of the visual mechanism to *light* obscures the similarity of the process to what is here called adaptation with negative after-effect, but it may be urged that the difficulty is mainly terminological.[5]

Temperature: warmth and cold—The characteristics of a sensory opposition-series are very clearly exemplified in this dimension. The opposition of the warm and cold qualities is clear-cut despite dubious theories of their fusion to yield heat. The neutral quality is definite, it is quite obviously a norm, and it constitutes the psychological point of reference for the series. The limits of the series are furnished by the

[5] It has been maintained that black and white are not antagonistic qualities like complementary hues because when mixed on a color-wheel they do not inhibit one another but fuse instead. Whether gray is considered a product of fusion or of inhibition is perhaps a matter of choice. It must be admitted, however, that the brightness-scale is a less perfect example of the opposition series than other sensory dimensions.

transition to heat and pain qualities at the upper end and pain at the lower end (**15**). Consequently, it is to be expected that adaptation and the opposite effect of this adaptation upon subsequent stimuli would be prominently exhibited, and such is the case. If a stimulus at about 33° C. feels neutral, as it normally does, and the skin is then adapted to warmth at 36° C., 33° feels cold and all stimuli over a wide range should feel colder than they would have felt under the earlier conditions. How far up and down the scale the shift remains uniform is not known but this should be susceptible to an experimental test. The norm of the temperature-series (the psychological zero) is so adaptable that it may be raised as high as 39° C., whereupon 37° C. feels cold, or it may fall as low as 11° C., whereupon 12° C. feels warm (**1**). Within this range any process of adaptation is complete; the discrepancy between the prolonged quality and the norm wholly disappears; the temperature perception becomes normal or neutral. Some time may be required for adaptation to reach the level where, for example, a finger immersed in cold water yields no temperature experience whatever, but the fact that it does so seems to be well established. With respect to this flexibility of the stimulus-quality correspondence, the temperature sensitivity of the skin seems to be similar to the general brightness sensitivity of the retina. Furthermore, as in the case of both color and brightness sensitivity, when the adapting stimulus is localized rather than general the effect is confined to the stimulated area of the sensitive field. Localized temperature adaptation may, however, be complete where localized visual adaptation under most circumstances is not.

The qualities of a simple line—The sensory qualities which have so far been discussed are orthodox ones which no one would dispute. The proposition that a simple line is a sensory quality—or character, or modality—is less orthodox. William James argued convincingly in 1890 that a line was a sensation pure and simple (**13**, p. 152), but the accepted list of sensory categories has never included it, even though it possesses all the necessary 'attributes.' Recently, as a part

of the reaction against the older structuralistic categories, contour and the figure-ground phenomenon have been accepted as basic visual processes. The visual *line*, however, has been left out of account by both schools of thought. It is logical to suppose that line, the accompaniment of any areal difference of color within the visual field, is an even more elementary process than is contour or figure. Things are seen in the first analysis because they are delimited in vision, and this delimitation involves the formation of a line. The fact that a line may have the function of enclosing or serving as a contour with an 'inside' and an 'outside,' yielding thereby a figure on a ground, may be considered a separate step. A line is a simple, unanalyzable and fundamental mode of visual experience.

Against the above assertions there is set, of course, the historically conditioned tendency to distinguish sharply between sensation and perception, between secondary and primary or subjective and objective qualities. A line, it would be contended, is no sensation; it is a thing with objective existence. Since a sensation refers to a receptive process in the organism and a perception refers to an object, linearity must be perceptual. For the present it will only be suggested that this historical dichotomy is a false one. *Sensory* and *perceptual* are here assumed to be useful relative terms which can not be distinguished by any absolute criterion.

A line, or any selected portion of a line, may be said to have two qualitative dimensions which define it psychologically in the same way that hue, brightness and saturation define a color. They are its shape and its direction. For lines in the frontal plane, shape means the convex, straight, or concave quality of the line or the segment; direction means the standard (vertical or horizontal), or inclined quality. The mathematical equivalents of these sensory qualities—the direction and the shape of a line—are expressed as the first and second derivatives at any point, that is to say, as the slope and as the way in which the slope is changing.

Both these qualities fall into dimensions which fulfill the requirements of an opposition series. Both manifest adapta-

tion with negative after-effect in a manner which points to their kinship with sensory processes.

Linear shape: convex-straight-concave—A line is usually straight, but this standard quality is only the neutral one between two opposite qualities which a line may bear. Taken as a whole or in any part which one wishes to consider, the line may be curved or bent in either of two directions each of which is complementary to the other. These qualities of non-rectilinearity may vary in intensity. Like opposite saturations of color, they intensify as they deviate from the norm. A sharp bend may be regarded as an intense non-rectilinearity confined to a small segment of the line, a gradual curve as a less intense non-rectilinearity spread out over a larger segment. Both the bend and the curve are varieties of linear shape. For lack of a better term, 'curvature' will be employed generically. The various degrees of curvature, then, together with the norm, form an opposition series. The limits of this particular series are vague and unspecific. It is impossible to say what the maximum curvature of a line can be, since a high degree of curvature on a sufficiently extended line begins to be a contour instead of a line.

Adaptation with negative after-effect for curvature of a line has been reported by the writer previously (**8**). If a subject is required either to fixate or merely to look at a curved line, the quality of curvature decreases in the course of time and *in that particular region of the subjective visual field* a straight line appears curved the other way. The same is true of a bent line if the subject's gaze is confined to the section of the line where the bend appears. The phenomenon is quite independent of the direction or orientation of the line as a whole. If curvature is measured in units of displacement at the middle of a line of constant length, then the amount of decrease in curvature during adaptation is equal to the apparent opposite curvature of a straight line. There has occurred a uniform shift in the curvature-quality of any line seen in the adapted area. In other words, when a retinal curved line is represented phenomenally by a less curved line, then a slightly curved line is correlated phenomenally with a

straight line, and a straight line with an oppositely curved line. A displacement of several millimeters in a 30 cm. line may take place with a five minute period of adaptation and the after-effect will persist for several minutes thereafter. The phenomenon has been verified by Bales and Follansbee (**2**).

This effect can not be classified as an illusion of judgment (although all of the effects we are discussing are fundamentally analogous to judgment-contrast) if for no other reason than because, like the after-image, it is localized. Curvature-adaptation bears the earmarks of what has traditionally been called a sensory process. Like color-, brightness- and temperature-adaptation it can be represented as a shift of the physical-phenomenal correspondence of such a sort as to make the present sensory quality more nearly normal. This shift, however, is very slight in amount as compared to the dimensions so far considered; the physical-phenomenal correspondence is relatively rigid in contrast to the flexible correspondence found in temperature-sensitivity. The concept of relative rigidity or flexibility of this dimensional correspondence might serve as a partial substitute for the ancient concept of primary and secondary qualities.

Tactual-kinæsthetic shape of an edge—A line is 'perceptual' rather than 'sensory,' it might be argued, because it is present to more than one sense. In the form of an *edge* it may not only be seen but touched and felt. It is true of course that objects are delimited tactually as well as visually and that surfaces and lines are haptic as well as visual data. But a tactual edge is subject to adaptation with negative after-effect no less than is a visual line. As the writer has demonstrated (**8**, p. 17), if a concave (or convex) edge is actively felt by a blindfolded subject for a few minutes, the curvature decreases and a straight edge then feels convex (or concave). The shift in curvature represents a displacement of over 1 cm. in a 30 cm. line. An edge which is curved in the same direction feels straight and by this determination the effect can be measured.

Linear direction: standard and tilted—The directional quality of a line or a segment of a line may abstractly be treated independently of its shape, although the two are intimately related. Within the frontal plane, direction is discriminated with reference to the norms of horizontal and vertical. These standard directions are set between opposite qualities of what can be called 'tilt.' Psychologically a tilt with reference to the vertical may be either to the right or to the left. Equally, the vertical is simply that neutral direction which is tilted neither to right nor to left. In this case, it is not difficult to understand what is meant by saying that the opposition-series is a discriminatory unit or that the qualities are interdependent. The limits or ends of the opposition-series whose norm is the vertical interlock with those of the series whose norm is the horizontal. Consequently at 45° clockwise from the vertical the experienced tilt is equivocal; it may be a tilt to the right of the vertical or to the left of the horizontal. The same, conversely, is true of the other 45° position.

Psychologically, then, the direction of a seen line is an immediately sensed quality which may vary within two interlocking dimensions of the type in which we are interested. These opposition series have their *centers* at the horizontal and vertical—not their limits. The dimension *beginning* with the vertical and *ending* with the horizontal would constitute what has been called a transition series.

This description is not entirely *a priori* since it derives from an experimental setting (**9**, **10**, **17**). It can be demonstrated that a process analogous to adaptation with negative after-effect occurs in this type of perception also (**9**, **10**). In the course of a continued fixation or inspection of a tilted line the inclination appears to decrease slightly and a line objectively vertical (or horizontal) thereupon looks tilted in the opposite direction. After a 5 min. period of adaptation the shift of linear direction may be 2° or 3°. A 10° tilt looks like 8°, 2° looks vertical, and the vertical looks like − 2°. The effect does not apply to the visual field as a whole but is roughly limited to the region previously occupied by the

stimulus-line. When one axis has been altered in this manner the other axis is found to be altered in the same way, although not to the same degree. In other words, the rotatory shift in the apparent direction of a stimulus-line *tends* to be the same throughout the whole gamut of visual directions in the affected area. In accordance with our general formula, we may suppose that a prolonged perception of tilt adapts in the direction of its vertical norm if it is tilted from the vertical (or its horizontal norm if it is tilted from the horizontal), carrying with it the qualities of its own dimension and even to some degree the qualities of the other dimension. A tilt of 45°, on this theory, should not show any adaptation toward either norm, and actually it does not (**9**, **10**).

Tactual-kinæsthetic direction—It is not difficult to show that the direction of a line in the frontal plane, like its quality of shape, behaves in the same way when actively felt as when seen. A yardstick mounted on a bearing at its midpoint and supported in front of a blindfolded subject so that he can put one hand on either end and adjust its direction to the horizontal or vertical position will serve to demonstrate the phenomenon. Under normal conditions the stick can be set at horizontal with some accuracy. But after a few minutes of actively feeling the stick in a position tilted down to the right from the horizontal, the abnormality diminishes, the actual horizontal then feels tilted down to the left, and an actual tilt of several degrees to the right feels horizontal.

Visual Movement—Since the investigations of the phi-phenomenon, it is no longer a novelty to suggest that movement is akin to a sensory quality, or at least to suggest that it is not a composite of other sensations. But here, again, a sharp distinction between sensory and perceptual processes leads to unprofitable arguments. Motion is surely a dimension of visual experience. And, what is more important to us, some motions are the opposites of others. Their opposition is of a very simple sort—opposition of direction. In fact any experience of motion can be given its place in an opposition series which varies from the highest perceptible speed of movement in one direction through immobility to the highest

possible intensity in the opposite direction. There are of course as many of these oppositional dimensions as there are directions in visual space. It may at first appear a little forced to claim that immobility is itself a visual quality of objects—the neutral between opposite qualities of movement —but this normal immobility of things is definable only as absence of motion, and is discriminable only with reference to these qualities, and is therefore as truly a quality of experience as is motion.

According to the formula which we have proposed, a prolonged experience of movement in any part of the visual field should decrease in speed in the direction of becoming neutral, and therewith a lesser actual motion in the same direction as before should appear immobile, and an immobile stimulus should appear to move in the opposite direction. The last of these statements is the familiar 'after-image' of movement, which has been rather thoroughly investigated (**26**). The second statement is less familiar, but it also represents a fact. Stated in another way, the after-image of movement may be just cancelled by a slow objective movement of the stimulus field in the same direction as before (**6**). But the first statement, which predicts adaptation, can not be verified so far as the writer knows by any reference to the literature of the phenomenon. Our hypothesis demands, however, that adaptation be the invariable *condition* of any negative after-effect.

A simple experiment can be made which demonstrates that adaptation to movement does occur. Two contiguous openings with shutters are cut in a screen and a moving surface is set up behind them. The observer, who should fixate a point on the screen, will find that the two fields will appear to move at the same speed when both shutters are opened at the same time. But if one field is exposed first for a short time and then the other window is opened, the first field will look slower than the second, and the two areas of movement may not coincide in apparent speed for some seconds. The difference seems to be more nearly optimal if

the two windows are close together and if their relative position is offset from the line of the movement.

Visual movement, then, is analogous to the other dimensions we have so far considered. The serial shift of the impressions from their usual stimulus-base is furthermore a localized effect in the case of movement as it is in the case of color, brightness, temperature, visual shape, and visual direction of a line.[6]

Tactual movement—An impression of movement is a datum which, like the impression of a line or edge, cuts across more than one sense department. Whatever the 'existential correlate' of a movement, it still has the quality of being *movement*—whether it is seen, or felt on the skin, or even sensed kinæsthetically. It is therefore not unreasonable that tactual movement should behave like visual movement with respect to adaptation and negative after-effect.

Thalman has shown clearly that an opposite after-effect does occur (**18**). If a moving belt of rough cloth is made to press against the skin for a short period and then the movement is stopped, there will be an impression of tactual movement in the opposite direction, occasionally "as clear as if the cloth had been set going backward" (p. 275). Thalman does not report that the movement slowed down during the period, but he does say that when the impression of movement was weak by reason of using a smooth rather than a rough cloth, "at times the movement adapted out and only a dull pressure remained" (p. 272). The area of the movement after-effect was sometimes clearly defined and sometimes diffuse but in general it seemed to be limited to the stimulated region of the skin. It is probable therefore that tactual movement parallels the other dimensions in possessing the functional characteristics which have been pointed out.

Taste—A number of analogous types of experience, all of them relatively simple, have now been listed. It is probable

[6] The negative after-effect, when only one eye has been stimulated, does not appear in the corresponding area of the unstimulated eye in the case of color and brightness, but does appear there in the case of curvature, tilt and movement (**8, 9, 10**). Movement adaptation resembles that for curvature and tilt in being incomplete.

that the list is not complete but this is not essential, since our purpose has been only to establish the generality of a number of principles which center around the phenomenon of adaptation with negative after-effect. Some dimensions, such as auditory pitch and visual size or distance, do not undergo adaptation at all. Neither does temporal duration. Others, such as cutaneous pressure and lifted weight and olfactory intensity, do show adaptation, but these are intensive dimensions and the adaptation is not accompanied by a negative after-effect. Still others, such as color, temperature and movement, fall into the type with which we have been concerned. Between these three kinds of dimensions, however, there need not be a sharp cleavage.

An example of a sense in which serial opposition is only partial and where, accordingly, adaptation is accompanied by negative after-effect in only an imperfect manner, is taste. Between the qualities of sweet and sour there is a sort of opposition, not however such that the one can neutralize the other, as in witnessed by the taste of lemonade. Nevertheless sweet and sour are so related that after adaptation to sour, distilled water tastes sweet and sweet tastes sweeter. After adaptation to sweet, it is at least true that sour is enhanced. In general, however, the after-effects of taste are more complicated and specific than this. The sensory dimensions between the four qualities of taste are more like transition-series than they are like opposition-series. The basic structure of the sense is not well understood.

Kinæsthetic right and left—Of the three dimensions of visual space, up-down, right-left, and near-far, referring now to location rather than to direction, one constitutes an opposition series, namely the series of spatial positions from left to right. The position at 'straight ahead' is neutral. This sensory dimension, either in its visual or in its kinæsthetic mode, should therefore manifest adaptation with negative after-effect. It can easily be demonstrated by means of a simple hand pointing experiment that the kinæsthetic neutral shifts in the manner demanded by theory, but a thorough experi-

ment is needed. The hypothesis should likewise be tested for visual localization.

Rotatory movement—Still another case of an oppositional dimension is furnished by the experiences of opposite rotatory movement, the stimuli for which are not the absolute angular velocities of the body but its accelerations, whether positive or negative, and their respective directions. The end of a period of acceleration, whether positive or negative, whether it teminates in uniform motion or in rest, is followed by a positive dying away of the movement-experience and then by a negative after-effect (7).

Pleasantness and unpleasantness—The hedonic series should be mentioned in this connection. There seems to be no doubt that affective adaptation occurs, nor that when this happens for one stimulus-item of an affective series there is a corresponding shift of the affective values of other items (3). Presumably the members of the series must be discriminatively related to one another for this to occur. It is suggested that the principle here is the same as elsewhere, that there has occurred a shift in the correspondence between the stimulus-series and the affective dimension.

Simultaneous or areal contrast—A fairly complete survey has now been made of sensory phenomena classifiable as adaptation with negative after-effect. No mention has been made, however, of the phenomenon of simultaneous contrast, although the possibility that this principle too might be found to operate in several sense-departments is an obvious one. Contrast is similar to adaptation with negative after-effect in that both phenomena are conditioned by the existence of opposite sensory qualities. Furthermore, both operate on the principle of a serial shift. To take an example from chromatic contrast, a large field of blue has an effect upon a smaller enclosed area such that if the latter is a less saturated blue it will appear still less saturated, if it is gray it will appear yellow, and if it is yellow it will appear more saturated. It is sometimes assumed that both adaptation and contrast are instances of a common law of contrast, one merely being

simultaneous and the other successive.[7] But this is a very superficial assumption, since their similarity ends with the fact that they both involve a serial shift in an appositive dimension. The qualitative shift in the case of contrast is a very different thing from that in the case of adaptation. The former is simply a part of the immediate perceptual process; the latter is a gradual adjustment of the correspondence between stimulus and quality to one set of conditions with a subsequent readjustment of it to the ensuing normal set of conditions. Contrast is instantaneous, like illusions or like the various 'constancy' phenomena to which it is apparently related (**14**); adaptation is a gradual process. Contrast is a matter of the relations between two spatial areas in the field; adaptation is referable to a single stimulated area. Contrast is said to be a reciprocal effect between areas, the function of which is to enhance the differences between stimuli and facilitate spatial discrimination; this may be true but it is surely not true that a negative after-effect increases the difference between two successive stimuli and thereby "facilitates successive discrimination" (**5**, p. 287). The adapting stimulus and the reacting stimulus are not more dissimilar after adaptation than they were before; the only change is a shift of both toward the other end of the scale. In fact there is no evidence that 'successive contrast' has anything at all to do with contrast between successive stimuli. With respect to simultaneous stimuli, Titchener has pointed out (**19**, p. 78) that chromatic adaptation is essentially a process tending to level all differences in the visual field, and it might be added that all negative after-effects are simply incidental accompaniments of this process.

Simultaneous, or as it might better be called, areal contrast is therefore not to be identified with adaptation and negative after-effect, although like the latter it can be shown to operate in an essentially similar way in a number of different sensory dimensions. Areal contrast, under the conditions most

[7] Von Kries (23, p. 239) states that the law of contrast is, in effect, this: when impressions can be arranged in a series, an element produced in *temporal or spatial proximity* to another element is displaced away from the latter. This principle, says Von Kries, applies very widely.

favorable for it, may be described generally by saying that *the perception of a non-normal quality over a large area of the sensory field is accompanied by an effect on an enclosed region of differing stimulus-value within the area altering its quality in a direction opposite to the surrounding quality.*

Areal contrast, as thus described, is a familiar phenomenon in the dimensions of color and of brightness. The facts need not be reviewed. That contrast also occurs in cutaneous temperature is less familiar, but such is the case (**11**, also **13**, p. 14). A neutral area within a ring of warmth feels cold and within a ring of cold feels warm. The same is true for visual movement (**24**, **25**) a common example being the apparent opposite movement of the moon when seen through drifting clouds. It is quite possible that tactual movement would also yield areal contrast if Thalman's technique for investigating the negative after-effect (**18**) were applied to the problem. The writer has shown that the qualities of a visual line also manifest contrast. If a straight line is seen on a background of curved lines it appears curved the other way (**8**), and if a vertical or a horizontal line is seen on a background of tilted lines it appears tilted the other way (**9**, **10**). Contrast occurs, therefore, in the dimensions of color, brightness, temperature, movement, linear shape, linear direction, and possibly in others. It does not occur in the kinæsthetically sensed dimensions of the curvature or tilt of an edge, nor in fact in any sensory or cognitive dimension in which comparisons can not be made simultaneously. It is logical that areal contrast, occurring in a sensory *field*, should be exemplified only in the visual and the cutaneous sense.

Implications for a physiological explanation—Positive after-effects, after-images, or after-excitations occur in many types of sensitivity, including some which show negative after-effects (brightness, color) and some which do not (pressure). It has usually been supposed that the positive after-effect is to be explained by an after-discharge of the same receptor-process which produced the sensation, and that like the fact of latency it is a reflection of the inertia or temporal lag of this process. Now, in the case of the after-

effects of color and brightness and of rotatory movement of the head, positive and negative effects may under some circumstances occur together, alternating in a way which suggests an oscillatory return to equilibrium. The relation between the positive and the negative effect has even been represented by a diagram showing pendular waves of excitation oscillating in time above and below the abscissa. The implication of this diagram is that the negative after-effect is, like the positive, merely an excitatory process which outlasts the stimulus—an opposite process of some sort, to be sure, but still an excitatory process. The negative and the positive effect would be cognate phenomena for both of which a rather simple physiological explanation is implied.

It will have been noticed that the present discussion of the generalized negative after-effect does not propose any physiological theory whatever to explain it. Our contention is only that the effect is a corollary of adaptation and consists of a serial shift in the stimulus-quality correspondence. If this description is correct, physiological theories, whether in terms of opposite excitatory processes or of fatigue or reduced sensitivity of the receptor, or of some other mechanism, must account for the whole description, including the adaptation, and can not assume that the negative after-effect is no more than a simple process of after-discharge. Premature physiological explanations, often without much study of the phenomenon to be explained, have been a very effective way of choking off further research in psychology.

The formula has been advanced that a persistent quality, if it belongs to the type characterized by serial opposition, diminishes in the direction of becoming normal, and that accordingly the quality evoked by any stimulus of the dimension is shifted toward the opposite quality. Negative after-effect is a by-product or incident of the primary fact of *adaptation to a norm.* This is the fact which a physiological theory must first account for. The process by which a system reaches equilibrium at once suggests itself as applicable. A state of adaptation might be a state of physiological equilibrium. But it is important to realize that the kind of equi-

librium required for an adequate theory is not an equilibrium in an isolated physiological system; there is required instead an equilibrium between inner and outer conditions, *i.e.*, in the system which includes both organism and environment. There is a shift in the *serial correspondence between stimuli and experiences*, and it can be supposed that this shift is of a sort which, in the long run, tends to keep the experiential norm, *i.e.*, the neutral quality, in correspondence with the norm of external conditions. On the stimulus side, a persistent or prolonged condition is one which perforce either is already statistically normal or tends to become so. A normal condition of the physical environment, normal temperature for example, is one which is recurrent and which is more prolonged than the abnormal conditions. Accordingly, on the experiential side, we observe a tendency for a prolonged or persistent quality to become psychologically normal—the neutral quality of its dimension. It is as if a persistent condition of the environment tended to become the normal quality of the phenomenal world—a not unreasonable assumption.[8] This general principle, then, when it operates locally by virtue of local persistent stimulation, might be the basis of adaptation. Negative after-effect would be a case of re-adaptation to the persistent condition which had previously existed. Both could be included under the formula of 'the adjustment of inner to outer conditions.' It should be emphasized that equilibrium of this comprehensive sort is not a simple physical or physiological process. Equilibrium in the sense organ or even an equilibrium of forces in the brain is not enough to explain the phenomenon.

The hypotheses which a comprehensive theory has to go on are these: that the normal quality of any dimension is the most frequent one in past experience; that the normal quality is correlated with the most stable physiological condition—the one involving the least output of energy; that the normal

[8] There is no use in debating whether the previous norm (gray, vertical, neutral temperature) tends to become the present persisting quality or whether the quality tends to become the norm, since they are wholly relative to one another. Neither alternative is an accurate statement, since the shift is one of correspondence between series, not of position within a series.

quality is correlated in the long run with the most stable and therefore the most frequent condition of the physical environment. How these and other hypotheses could be made the basis for a physiological theory of adaptation with negative after-effect, the writer does not at present know. It is probable that all norms do not have precisely the same biological basis. Some normal qualities, belonging to *sensory* dimensions, are largely the products of the sensory system itself. Such would be the 'natural' norms of gray and immobility. Other normal qualities, belonging to *cognitive* dimensions, are largely or wholly the products of past experience. An example would be the norm of a weight which is neither light nor heavy or an attitude which is neither pro-war nor anti-war. Other than this, little can be said toward proposing a theory.

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THE ÆSTHETIC EXPERIENCE: A PSYCHOLOGICAL DESCRIPTION

BY KATE HEVNER

It is not for the modern psychologist to deal with the two questions What is Beauty and What is Art. A tremendous mass of material has accumulated around them, reaching far back into the centuries, extending widely over many different fields and often running deeply into esoteric and contradictory channels. Facts, theories and researches have been piled up by artists, critics, historians and experimentalists until the richness of the accumulated lore is like the legendary fortunes of the Arabian Nights. The casual inquirer of today can be only amazed and delighted. He can not hope to comprehend or to make full use of such a wealth of material. Even among the philosophers and critics it is only the specialist who attempts to compose the modern answers.

The question to which the psychologist may properly offer his contribution is a simpler and more restricted question entirely within the scope and history of psychology as a laboratory science: What is the nature of the æsthetic experience. The answer requires a description of all the activities of mind and body during the experience of enjoyment or appreciation. It limits the psychologist precisely to the materials and concepts of his own science, even though the data for the psychological analysis come as often from poet, painter, composer, actor or humorist as from the experimental laboratory. Without these supplementary reports from amateur and connoisseur the psychologist could not reconstruct the æsthetic experience. His task is to translate them into modern terminology and to eliminate and modify until the artists' data square with the facts and theories of psychology in general.

So varied are the beauties of today—music, painting, drama, sports, nature—and so individualistic the ways of

enjoying them that the scholar who offers to describe *the* æsthetic experience might seem as much of a charlatan as the doctor who prescribes one single nostrum for all sorts of diseases. Nevertheless it is the urgent duty of the psychologist to attempt such a description. He must transform ecstasy, inspiration and genius into terms which every amateur can use in understanding and developing his own artistic enthusiasms. He must make his analysis complete, accurate and up-to-date so that the critic and philosopher, all those who teach, interpret and formulate the larger concepts of Art and Beauty may turn to it with confidence and with profit.

As a point of departure we will choose some obvious bit of experience, easily identified by all observers, and designating this as the truly æsthetic moment, proceed to lead the reader through a more precise and elaborate explanation. For this first tentative definition, we shall designate as æsthetic any moment when an individual is moved to say or to feel, "How beautiful that is!" The stimulus which evoked this attitude need give us no concern at the moment. It may be a landscape, a cathedral, a sonnet, a forward pass, a lullaby—something as worn and trite as 'The Road to Mandalay' or something crude and tentative that never before has touched a responsive chord. We specify only that the beholder be affected by it to the extent that such a comment rises spontaneously to his lips, that for him, the object has moved him to an awareness of its beauty.

It is usually an experience with a pleasant affective tone, though not necessarily so, and it stands out a little from the general flow of mental activity with a certain dignity, intensity and unity so that one may recall it later as a definite experience. It sets itself apart from the more common attitudes of daily life so that as it passes away one turns back to them with a distinct feeling of having made a transition.

This slight turning away from the usual preoccupations, or pause for the realization of the significance of an experience of course allows for a thousand individual variations, and at this point some readers will have a much clearer idea than others of what it is that constitutes the æsthetic experience.

To some by their natural inclination and favorable environment the æsthetic experience is frequent and well defined. To others such a moment may be infrequent, undifferentiated and elusive. But there can be scarcely anyone to whom such moments are entirely unknown, and it is the privilege of the reader to challenge every paragraph in terms of his own experience. Any discussion of æsthetics should serve the reader merely as an aid in his own introspection, in recalling, identifying and understanding his own enjoyment. Yet he must remember that the appreciation of art is after all a mental function, a psychological process, and is therefore conditioned by differences in personality, training, capacity, physique, etc. The connoisseur, failing to allow for these important individual differences, has often lost his audience by making his definitions too arbitrary and circumscribed, and the amateur, expecting something styled more exactly to his own demands, has likewise failed to recognize the identity of his own experience with the more conventional or esoteric types.

Even the more sophisticated have expected that the psychologists would prescribe a definite character for the æsthetic experience in much the same way that they have set up the categories for sensation, ideation, perception, emotion, and the like. Sensation, for example, though it never actually occurs alone and in a pure state, may be clearly differentiated from such functions as feeling, perceiving, remembering etc., and the concept thus derived is a helpful step in the understanding of the totality of human behavior and a necessary one in experimental investigation. But the æsthetic moment, contrary to these expectations, can not be subsumed under any of the well known partials in the complex of human activity. It is neither this one nor that one to the exclusion of all others. Nor can any category be added as a parallel to these other functions uniquely characterized and mutually exclusive of all. The æsthetic experience is rather a blend, a complex, a combination of many activities, with borrowings from practically every one of the other functions, and a unity that derives from the subjective aspects and diffuse bodily

responses rather than from the compact means-to-end objective set that organizes most of the other complex activity of daily life.

Our insistence on the complexity of the æsthetic experience means that we conceive it as a composite of many different activities occurring simultaneously. Some of them function automatically and subconsciously, others require effort and direction and the attention is therefore shifting constantly from one to the other. As the attention shifts, the experience may seem at one time purely emotional, at another highly intellectual or wholly sensuous. It is complex in the same way that driving an automobile is complex and the same difficulties arise in describing and defining the æsthetic experience as in limiting and explaining such an activity as driving. A round table discussion of driving to discover its essence and to define and relate its elements would prove it to be as elusive and mysterious as the æsthetic moment.

First, the æsthetic experience is an active, an intensely active, state of mind and body, not at all the passive acquiescence which appearances sometimes seem to imply. To be sure we sit at leisure to enjoy our music, we pause inactive to gaze at a picture, and many of our æsthetic experiences take place while we are in the more quiet bodily attitudes. The amateur has therefore often believed that we must be relaxed and limp, drained of our own initiative and energy so that the reaction from the æsthetic object may flow over us unresisting. Such figurative language has thwarted perhaps the attempts of many a novitiate who has tried to penetrate the mystery of appreciation by this method. No attitude could be more inauspicious. Appreciation requires alertness of mind and body. Attention must be directed wholeheartedly toward the objective stimulus and 'attention' means that a state of readiness, of partial contraction, is being maintained by the muscles of the body, that the eyes are turned toward the stimulus and actively focussed there, that the ears are catching every detail of sound, that the mind follows the senses to supplement and interpret. It means also that the musculature is not occupied with any other activity, that it

is free to respond to the movement and the rhythm of the stimulus, that is actively seeking to follow every suggestion, to emphasize the experience at every point. Relaxation is lassitude and finally oblivion and sleep. Appreciation is muscle tonus, muscle coördination; it is activity, tensions, responses. It is awareness, alertness, animation, energy.

Because it is a moment of concentrated attention, and because it does require muscle tension and activity, these are the twin reasons why the experience is transitory and shifting. As the attention shifts and fluctuates, the æsthetic moment passes; as the fatigue develops in the muscles, the intensity of the enjoyment fades. To claim otherwise is to claim the psychologically impossible. To expect of an evening's concert a period of unremitting æsthetic pleasure, of unmitigated satisfaction and delectation is the unmistakable mark of the amateur. To feign such pleasure, to affect such a continuous absorption is æsthetically the unpardonable sin. To sustain the attitude over longer and longer periods of time is the proper object of the daily lesson in art appreciation, the final skill of the connoisseur.

The kind of alert activity characteristic of true appreciation is not something which any naive observer may happen into immediately when he is confronted by an art object any more than the correct stance, the perfect swing and the long drive are characteristic of the first round for the amateur golfer. The habits of mind and body which enable the enthusiast to follow with sustained attention a Cézanne landscape or a Beethoven Symphony are as much a matter of practice skill as the more obvious coördinations of the trained athlete.

A scientist might place before his student a single drop of water and ask him to sit for an hour observing it carefully. But even the most conscientious student can not find enough of interest to keep his attention fixed beyond the first few minutes unless there comes between himself and the tiny drop of water the powerful lens of the microscope. Then he will see in it a hundred details of life and activity which can hold his interest easily for long periods of time. And in art

even more than in science the novice must have an instrument which enlarges all his powers of observation and understanding. This instrument is his developed habits of perception and without these habits the beauties of the objective world can make no impression upon him.

It is one thing to declare that the truly appreciative person sees much more than the untrained when both are directing their attention toward a beautiful object but it is quite another to specify exactly what it is that the expert perceives. And it is still another to explain how the connoisseur has acquired his superior observational powers and to develop a series of exercises organized and graded in difficulty so that the amateur may begin his daily practice. As to the exercises, we can do no more than offer some few suggestions, for that is a matter for the professional educator, while as psychologist we must make it our task to differentiate clearly those details of experience upon which the attention is fixed during the æsthetic attitude and which therefore are characteristic of the observation of the connoisseur.

Sensations themselves claim much more of the attention in this attitude than in other attitudes of life. Because of the economy demanded in our ordinary attitudes we pay the minimum of attention to our sensations, using them only as cues from which to catch the significance for further reaction. The sound of the clock striking enters consciousness only as an indication of lunch time; the sight of the clouds serves only to set in motion the business of closing the windows against the storm. In such cases we react to our sensations strictly in terms of their meaning. But in the æsthetic attitude we linger over the sensations as pure sensations, following the reverberations of the sounds, inhaling deeply of the aroma, tracing the movements, and feeling the brightnesses. We dwell on the qualities and intensities of the colors, the shapes, the sizes, the blends, the richness, the extensity and intensity, experiencing them not only with their proper sense organs but with the whole body. We follow outlines and surfaces with eye movements and muscular tensions, interpreting one sense by means of another and translating sounds and sights

into kinæsthetic experiences, the better to apprehend them and to enhance and intensify the original sensations.

Along with this keener attention to the qualities of the sensations, their relations to each other will also be developed. Some of them belong together and are experienced as a unit. Even for the most naive observer the succession of tones becomes a melody and the perception of such a simple relationship requires no conscious effort, no further practice. But the other elements of a musical composition must also be organized into units and reorganized into still larger units until the process of perceiving the piece as a unified whole is an immediate and effortless achievement. There is a melody in the bass which must be discerned and the progress of the harmony must be followed, first independently and then in relation to the various melodies. The separate phrases of the melody must be identified so that they may be recognized when the composer uses them in different fashions. We must hear the repetitions and the contrasts, be alert to variation, elaboration, ornament. We must concentrate our attention first on one element and then on another, devoting all our bodily energy first to the pulse of the rhythm and next to the developing and expanding of the harmony and then to the echoes and extensions of the melody, returning to this element or that until the whole becomes not one thin and simple unit of perception, but a rich and vivid experience, crowded with sense impression and quickened with muscle tensions.

In the graphic arts there are the same possibilities for enriching and enlivening the original experience, for emphasizing and relating the various parts. Take occasion to notice, for example, the pattern of one of the colors in some familiar picture. Locate all the separate bits of it and see them as one pattern. Find all the lines which turn in one direction. Observe them as a unit and feel the pull of them. Look for the different planes and distances, the nearest one, and the farthest one. Notice the brightnesses and dullnesses, the lights and shadows, and organize them into a pattern. Look at the picture with half shut eyes and see the parts that stand out from it. Relax the whole body and let the eye wander

over it lazily, observing the progress of the eye movements. Walk away and come upon it suddenly from a different angle. Look at it in a mirror and continue the search for new patterns. Try to memorize it, to imagine it different.

Of course by the end of such an exercise the observer will be utterly and indescribably bored with the picture, completely impatient and exasperated with the music. He will resent them as bitterly as the child resents his piano scales and his problems in long division. But we must remember that the objective was not the appreciation and enjoyment of the picture, but the building up of habits of observation, the awakening of the senses and the training of the perception so that the apprehension of the details will be ready and nimble. For if the skill in perception is slow and awkward, if the mere task of comprehending the form demands all the attention, there will be no time or energy left for the enjoyment of it. The pleasure of the total effect would be lost, just as the smack of a French epigram is lost to a beginner whose French is so poor that he must decipher each syllable with painstaking care. To achieve any pleasure in art, as in language, the facility must be so ready that as the sentence proceeds (or as the music proceeds) one is aware of the trend of the ideas and approaches the end with a certain foresight. Then the conclusion will be important as a fulfillment and it will be rich with satisfaction because it was wanted and needed. The moment for its enjoyment, however, must always be free. For the inexpert, the effort and confusion and uncertainty will crowd out the pleasure, and the experience can not be crowned with success.

And even though the enforced study of the 'Tragedy of Macbeth' or the Bach 'Inventions' may fill the unwilling victim with resentment and gloom, the process of acquiring apperceptive skill is not necessarily a dull and dreary process. It is not only the final and complete apprehension which secures the æsthetic thrill but for the willing and interested, it is every step in the process, every successive hearing of the music, every newly discovered outline in the pattern which may bring to us its increment of true æsthetic enjoyment.

Even the review of the past successes, the repetition and rehearsal of the old discoveries often affords keen satisfaction. So long as the last least bit of it can catch our wayward attention we shall still find the object beautiful and take from it an æsthetic pleasure.

That is why the beginner gets so much satisfaction apparently from merely recognizing and identifying the standard works of art as he seeks them out in museums or finds the hanging in his neighbors' parlors. His first pleasant lesson in their beauty was not so well learned that it can be recalled at will and only with the object actually present before him can he rehearse his earlier enjoyment of it. That is why the little ripple of approval ruffles the audience when the pianist returns for his encore and sounds the opening chords of the C# minor prelude. It is exactly like the child's pleasure in the hundredth telling of the fairy tale. He can anticipate every detail of it as it unfolds itself in the telling, but he could not recall it of his own volition. He can not foresee the end from the beginning nor yet from the middle—in fact not until that very last penultimate detail is set in place for him. When the music is completely known to us, when there is no slightest detail of it that escapes our anticipation, when memory serves all too well and curiosity is entirely dead, then it requires an effort to hold our attention upon it, and with that the pleasure is gone and we find the music wholly trite and thoroughly objectionable.

These perceptual habits and the details of the objective stimulus toward which they are directed comprise the formal aspects of art and many discussions and expositions of æsthetic matters have centered around them. Some critics have consciously taken the position that art is pure form and others have so neglected any other aspects that such a position is clearly implied. They have been completely occupied with the formal materials of beauty, the sounds, colors, lines, rhythms and those particular patterns and blendings which have become æsthetically pleasing to the mind of man. The justification for this point of view, together with the problem of art form, the reasons for the appearance of

certain forms rather than others, the evolution of forms and their dependence upon economic and social circumstance, are tremendous and absorbing problems but they are appropriate for the sociologist and philosopher; as psychologists we must renounce all such theories and speculations and continue rather with our enumeration of the details which occupy the attention of the observer in his æsthetic experience.

We have already noted the preoccupation with sensation, that is to say, with the sensuous enjoyment which the poets and critics have endlessly extolled. We have noted also the tendency to intellectualize the sensations, namely, to organize them into patterns and to discern their artistic form. Both of these activities we observed to be exactly contrary to the common day-to-day attitude which neglects every aspect of sensation except those which are necessary cues for further activity. Likewise in seeking the meaning of the sensations and perceptions the æsthetic attitude is again contrasted with the usual daily reaction in that it turns away from the useful, the personal and the concrete toward the fanciful, the impersonal and the abstract.

To give meaning to our sensations and perceptions, to project them upon the background of our previously accumulated experiences, ideas, intentions, beliefs and attitudes is a very deepseated human tendency. Every perception promptly associates itself with some detail of this background, some part of this stream of consciousness, and this reference to something outside itself we pronounce its meaning. For example, the meaning of certain garments as we catch sight of them hanging in our wardrobe may be, one after the other, something to be cleaned, something to be mended, something to wear tomorrow, something to be admired in, something we paid too much for, something we had a good time in, something to be discarded. In the æsthetic attitude these homely and concrete references give way to more abstract concepts. Out of the background of experience the beautiful stimulus brings forward such general concepts as dignity, strength, truth, awe or meanness, sin, death, or struggle, revolution, labor. It is not that we are never oc-

cupied in our daily routine with abstractions. When we are faced with such a simple practical problem as choosing between baked apple or chocolate mousse for dinner we make use of such abstractions as the state of our health, our financial standing, the caloric content of the food, etc., and to bring these necessary concepts to mind we engage in activities which we call reflecting, thinking, summarizing, evaluating. But in the æsthetic attitude these concepts and references are not so immediate and personal. To put it more properly, when the meanings are abstract, far removed, non-practical and impersonal we find in them an æsthetic quality. Because the adequate conception of them demands more of the effortful mental activities—recalling, summarizing, evaluating—they are characterized by a breadth, distance, largeness which gives them that sense of importance and mastery characteristic of the æsthetic moment. It is their infrequency and unusualness and difficulty that sets them apart and enshrines them, placing them a little above the plane of daily achievement. That is why the ugly—death, horror, deceit, angry passion—acquire so readily the æsthetic quality. In so far as these concepts are abstractions, unusual, and impersonal, their representation in consciousness requires effortful summarizing and evaluating which brings with it the largeness and breadth of the æsthetic moment. When vivid sense impression and emotional toning are also added—and these are very likely—the experiencing of these ugly realities has all the qualities to make it an æsthetic experience par excellence.

This sense of mastery, this insight, this consciousness of difficulty overcome is the invariable accompaniment perhaps even the sine qua non of the æsthetic experience. Insight is the sudden comprehension of the relation of the details of a certain experience which gives it a wholeness and fixes it definitely and completely into place among other concepts. We use the word 'sudden' because this wholeness can come only while all the numerous details are fresh in the memory so that their integration seems important, while the effort, the puzzling and the straining to organize them is vividly present. Without the felt effort and the remembered disorganization

the significance of even the most profound utterance becomes utterly trite and empty. The æsthetic moment is the realization of the felt want completely fulfilled. The deeper the want, the harder the struggle to fulfill it, the more mental and bodily activity involved, the greater the satisfaction.

It is not to be expected that activities such as those described above could take place without an emotional accompaniment, in fact it is the emotional accompaniment which helps to give these activities their importance and significance. The art object always has a moving effect. It appeals, as William James would say, to the bodily sounding board. It calls out some response of the affective kind which the psychologist would label emotion, feeling or mood.

In understanding the affective content of the æsthetic experience it is not of importance to differentiate specifically between emotion and feeling and mood but only to describe the various bodily responses which give the experience this particular quality. A genuine emotion, a physical response of more or less violence, with clenched fists, shaking knees, flushed face and fast, deep breathing, with visceral reactions and that familiar all-gone feeling in the pit of the stomach—such a stirred-up state of the whole organism is of course never present in the æsthetic experience. An experience of such violence would completely absorb all of the attention and there would be no awareness of the other necessary components, the sensations, perceptions and ideational activities. The emotional content of the æsthetic moment must rather be in the nature of a mood which we define as qualitatively like an emotion but a much paler and more diluted emotional state. It may be sustained over a much longer period of time and needs only a few of the characteristic bodily components to make itself felt. The gentlest stab of visceral reaction, the slight lifting of the head or the faint tightening of the throat may be sufficient to throw the glamour of emotion over an experience, to give it color and poignancy. A gesture or an attitude copied from an art object, a suggestion, conscious or unconscious, which finds its answer in a muscular or visceral response will serve to emotionalize the whole experience.

Even the bodily symptoms derived from a totally different source may lend their effects to a neutral stimulus, making it seem for a time a beautiful thing, as when the effects of certain drugs enhance all sensation and perception for short periods of time, giving all experience an æsthetic quality. The effects of the sex hormones likewise produce periods of heightened sensitivity and an emotional toning wherein otherwise drab personalities, objects and experiences are transposed into the realm of the æsthetic.

The æsthetic experience then does not, can not occur except upon a background of these bodily and visceral responses and they seem to give it poignancy, importance, brilliance, emphasis. They are usually in the nature of widespread and unlocalized responses, because to identify and localize them would require a fairly high degree of attention to them, and in the æsthetic experience the attention is always, one hundred per cent of it, on the art object. The bodily sensations must be in the background. When they become so prominent that the attention shifts to them, then the attitude is necessarily personal. One is thinking of his own self, his physical being, the art object is forgotten and the æsthetic attitude has disappeared.

Our description of the psychological processes which are involved in the æsthetic experience is now almost complete. It is an attentive state, with the musculature and all the senses alert and active, following every detail of the stimulus and making the experiencing of it a forceful and vivid awareness. With so much bodily activity in the perception of the stimulus, meaning is crowded into it richly and these meanings are the unusual, impersonal and abstract in contrast to the concrete and practical meanings of ordinary day to day activity. All of these activities are made more poignant because they occur upon a background of widespread and unlocalized bodily sensations especially from the involuntary muscles and viscera which give the experience affective or emotional qualities.

Along with this general description we will further differentiate two specific criteria of the genuinely æsthetic ex-

perience, which, to be sure, have already been mentioned in passing—(1) the attention must be centered on the beautiful object, and (2) there must be the feeling of insight, of comprehension, of significance, mastery.

If these criteria are correct, then this would mean that the truly æsthetic experience can not be of long duration for the constant shifting is the prime characteristic of attention and when the shift is toward practical matters, to the feelings or mood, to anything of a personal nature the attitude is for the moment lost. Likewise when the beholder is consciously reasoning, studying and evaluating the material, experiencing the effort and strain, the struggle, the defeat, his experience is not æsthetic. The true 'appreciation' then, the authentic experience of æsthetic enjoyment is a period of constant shifting from one attitude to another and the æsthetic moment is more vivid, in fact is only possible in contrast to the alternate periods of effort and of self-consciousness which are interspersed with it. As the attention fluctuates from one aspect of experience to the other, the æsthetic attitude comes and goes. It is therefore possible to spend an evening listening to a concert or reading a novel and to have a continuously growing experience. One may become more and more absorbed in the music so that the periods of æsthetic attitude are of longer and longer duration. The bodily responses are more and more intense and unified in tone, the sensations organize themselves more and more readily, the insight covers more and more of the details of the music structure. The personal and self-conscious attitudes are pushed farther and farther into the background.

Different schools and creeds may variously describe this occurrence as detachment, or disinterestedness, or repose in the object of beauty, or objectified pleasure; they may center the process around catharsis or significant form or empathy or distance or even intuition or social expression. Each of these theories emphasizes certain aspects of the experience of beauty and if their protagonists should attempt a subjective analysis, using exclusively modern psychological terminology many of the above paragraphs would undoubtedly be dupli-

cated. To the psychologist who is unhampered by any one certain philosophy of art and beauty and as an experimentalist, not even restrained by a systematic viewpoint in his own science, the phenomena seem best described by enumerating all the functions involved and finding among them those upon which the attention is particularly focussed.

It is again this matter of attention which gives us the key to training and growth in appreciation, in æsthetic enjoyment. It is a matter of acquiring the habit of attending to the art object, which means finding enough detail in the stimulus to engage all the bodily and intellectual activities so that the personal practical associations will not intrude. It means consciously shaking off these associations when they do intrude and returning to the stimulus and searching for further details, for fuller sensory experience, for richer perceptual patterns, for better and deeper insight into the meanings.

Training for the development of the affective side of the æsthetic experience is also necessary. It will be furthered perhaps by an introspective attitude, a conscious directing of the attention to the bodily tensions and pressures during any emotional or feeling states, so that they may be identified and their effects on experience differentiated. It involves consciously seeking new and different affective experiences and especially recalling and reliving past emotional experiences, putting them into words or postures or images so that the relation between the objective event and the bodily response is manifest. It means deliberately examining each art object for a suggestion of mood or feeling effect and assuming such bodily postures as seem appropriate to the suggestion, forcing oneself to find some such suggestion if it does not spontaneously occur. To the uninitiated such an approach to the finer feelings of the æsthetic attitude may seem crude and inappropriate but to any practicing artist, actor, or musician the suggestive effect of each detail of performance is evaluated and manipulated with painstaking accuracy and discrimination. The value of every gesture, every cadence, every chord progression is calculated to a nicety undreamed

of by the layman. Children especially must be helped and guided in the process of extracting the emotional effects from objective stimuli. They must be told to feel the strength and vigor of the martial rhythm, to shiver with a rippling descent of melody, to breathe deeply to feel the boldness of the bright color and broad design. They must be encouraged to find such reactions for themselves and to express whatever they apprehend with pleasure and eagerness.

In our discussion we have not only assumed an æsthetic experience occasioned by some of the standard objects of beauty, but we have assumed a typical, complete and well rounded experience, common to the more or less cultivated individual. Obviously the experience may be something different, something better or something rather less than the standard product we have described above. These variations, the individual differences always expected in psychology, we conceive as quantitative rather than qualitative differences. They are differences in degree, in intensity—permutations and combinations of the various components of the experience. Some of these expected differences we will outline briefly.

(1) Essentially, appreciation is a moment of fulfillment when the importance, the significance, of our present experience is uppermost in our minds and when our attention is on the objective stimulus which has occasioned the experience. The significance may arise, however, from a number of different sources, from the emotional thrill which shoots through the whole body, from the meaning, the idealogy which has such a strong pull on our own lines of thought, from the intensity and keenness of our sensations, or from our concentrated struggle to discern the pattern or meanings. The specific avenue of approach varies from time to time and from person to person.

(2) Individual differences in capacity for the æsthetic experience as well as in the acquisition of skill in appreciation are of course to be expected—the usual differences in talent and in training. Some enjoy music rather than the visual arts, some find depth rather than frequency of experience.

Others seem to enjoy in all directions and still others in none. Certainly there are large differences in sensory endowment which must show up in important ways. Ease and rapidity in the flow of ideas and associations must also have their effect, and the quickness and acuteness of the bodily responses in the affective life. The degree of muscle tonus, the glandular secretions and hormones, the body chemistry in general must also play a large part in the readiness to respond and in the susceptibility to the stimulus of the beautiful.

(3) The genesis of this particular kind of experience—the æsthetic—is as yet an unexplored process and a study of its development might fail to disclose the usual progress from simple to complex, from easy to difficult, from the rudimentary to the richly complete. The history of the æsthetic experience may show on the contrary a disappearing function. In its earlier stages it may be a continuous unembarassed forthright enjoyment of the sensuous and affective life, crowded with significant and important experiences and insights, which gradually gives way to the self conscious and the practical, to the restrained and colorless round of ordinary adult activities.

Beside the individual differences of the observer, there are obviously differences among art objects—the good, the great, the mediocre. We can not on the basis of our psychological data differentiate the one from the other, but we do know how to predict the success of an art work in terms of the audience it can command. The strength of its appeal is in direct proportion to the number of mental and bodily functions that it can stimulate. There are many avenues by which an experience may reach an absorbing significance, many details which may demand concentrated attention, many tricks to catch responses from the bodily sounding board. The art that will command the largest audience is the art that makes the largest number of appeals to the human mind and body, and that calls out these responses to their fullest extent and for their longest duration.

Theoretically any object may become a beautiful stimulus to some one individual. For that one person it has that

peculiar significance, commands that special attention and provides the glamorous feeling which makes it æsthetic. But we do not begin to designate it as an art object until many individuals find it beautiful, just as in the courts of law the belief of any one person may not be counted as a religion unless several other adherents are also found for it. If an object has merely a strong sensory appeal, strong, brilliant color, it might command the attention and stir the feelings of some few observers and provide for them a beautiful experience. Or an object may through its meanings, dignified or bizarre, or through its subtle emotional effects completely absorb the attention and make its significance felt for another small group. But if all the qualities of these two objects be combined in a third, then the number of observers who may be reached by its beauty has immediately been multiplied. And not only the numbers of its audience will be increased, but the first admirers will return to it oftener for rehearsing and enhancing their experience. When one avenue of appeal has exhausted itself, the other possibilities will attract them. If under the first simple outlines of beautiful form a more intricate pattern is hidden, the beauty has reached a still larger audience. Form alone may serve to make an object beautiful—line, proportion, balance, harmony, exquisite and enchanting pattern—it may count its admirers by the thousand. Equal thousands may be charmed by a less exquisite form if it is also the mold for poignant feelings, or if it carries a content rich in detail and widespread in its appeal. The Bach 'Inventions' are exquisite perfection of patterned sound, and even today they have their admiring audiences. The 'Toccatos,' 'Preludes' and 'Fugues' are more compelling, with their greater substance and their mood suggestions, their longer climaxes of form and feeling. But it is in the 'Masses' and the 'Passions' that Bach's most tremendous forcefulness is achieved, that his true greatness can make itself felt, for in these the perfection of form and the strong feeling is enhanced by the deep religious meanings which they are made to convey.

When one after another the increments of æsthetic pleasure are assured, when color is added to line and sound to color, when feeling is carried by form as well as by meanings, when meanings reach the most fundamental of human motives, the position of the art object becomes more and more secure. We begin to apply such terms as marvellous and sublime, and to refer to it as a masterpiece. Such generous praise must, indeed, be well earned and not in any mysterious fashion, but quite scientifically and mathematically by the infinite number and variety of human reactions which it is capable of arousing.

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JUDGMENT TODAY

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In the October issue of *The Psychological Exchange* an account was given of the writer's meagerly rewarded search for new and up-to-date materials on the psychology of the judgment. Not willing to abandon the quest, the writer prepared a one-item questionnaire on the judgment with the view to securing up-to-the-minute contributions on the topic. One hundred twenty-five questionnaire cards were sent to as many scholars of note, among them a few logicians, but most of them psychologists. These persons were asked to formulate (or quote) what they considered "the best psychological definition of a judgment." Some eighty replies were returned. Now that these have been carefully studied and compared, the writer is as much dismayed over the present status of the nature of judgment, as indicated to an extent in these replies, as over the earlier search for materials.

In the first place the replies are conspicuously lacking in similarity, not to say unanimity, of view. The definitions and other formulations offered vary all the way from the theory that the judgment is *central* to the psychology of cognition, to the extreme contention that the definition of a judgment is a task for lexicographers, not for psychologists. More than half, to be sure, take it for granted that 'judgment' is a psychological term and that the judgment itself is a psychological phenomenon, a reaction, and properly included in the subject matter of the science. Several, however, insist that logic is the only field in which it belongs. One of them consigned it to logic and epistemology. Another correspondent, after stating that 'judgment' is only a logical or a literary term, adds that it offers not one, but "n" *psychological* problems. (Does his last proposition imply that the judgment does, or does not, belong in psychology?)

One psychologist, who could not offer a definition out of context, reminds the writer that *volumes* have been written on the judgment; another suggests that "the primary sources" contain sufficient and satisfactory materials on the subject; still another hints—broadly enough—that what seventy-five to a hundred leading scholars and specialists of the day might have to say regarding the judgment would have little or no value for research purposes.

Of those who grant that the judgment does have a place in psychology, one notes that as a mental process it is psychological, but that as a mental product it is logical; and one selects the type of judgment known as 'existential' for assignment to logic. Two or three who seem to be just barely willing to allow the judgment a berth in the house of psychology caution that *if* it is a psychological phenomenon, it nevertheless has absolutely nothing unique, or even distinctive, about it, either in its psychological character, or in its physiological basis. Another small group who admit that psychology may properly take account of judgment stress the point that it can not possibly be defined apart from specific context, Warren's 'Dictionary of Psychology' to the contrary notwithstanding. Sixteen replies are references to one or both of the definitions given in that dictionary; and nine others contain definitions very similar to these. In this group of twenty-five was found the only noticeable trend toward agreement.

Those who seem convinced that the judgment does have distinctive psychological characteristics mentioned among others the following: (1) varying degree of belief or subjective assurance; (2) yes-no consciousness; (3) the aspect of a question answered, of a conflict resolved; (4) discriminatory character; (5) evaluative or appraisal character; (6) factor of predication, affirmation, denial, truth-claim; (7) comparison; (8) character of relational consciousness.

As against the statement, referred to above, that volumes have been written on the judgment, is another to the effect that one probably could not find even a subtopic, let alone a whole chapter, on judgment in any textbook of psychology,

and that although of course the mind is making judgments all the time, psychologists seem to be studying the results of these judgments, not their nature. The same correspondent does not hesitate to add that most psychologists use the term 'judgment' much as they use the terms 'dog' and 'baby,' that is, without definition of the same. It does appear that psychologists have left the task of defining the judgment to the logicians— and vice versa, as one mathematician puts it. If the judgment is a psychological reaction—and it would seem to be primarily just that—surely it is the task of the psychologists to give an account of it. The fact that it is difficult of definition is no good reason for consigning it, bag and baggage, to other fields, although perhaps we should say that for the present its place is in the realm of parapsychology, the realm of mental phenomena, of which, because they are introspectively observable but not introspectively analysable (as yet), we can say only *that* they are, not what or why they are. Then, too, the arguments for and against the place of the judgment in psychology *or* in logic strongly suggest that its proper place is in that 'between field,' to name which F. C. S. Schiller's clever term 'psychologic' might be used. The situation in which the judgment finds itself today reminds one of what happened to consciousness during the decade or more following 1913; and it is to be hoped that just as consciousness came again into its own, the judgment will do likewise. And with phenomena such as extrasensory perception turning up in this field, it is more than ever time the psychologists caught up on the judgment.

For the sake of inviting discussion and criticism the writer wishes to offer the following tentative descriptive definition of the judgment: a cognitive reaction initiated by a query, and involving inspection, discrimination, comparison, appraisal, and a degree of belief.

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